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OUTLINES

OF

MEDICAL AND SURGICAL ELECTRICITY.

DR. CAMPBELL.

OUTLINES

OF

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OF

MEDICAL AND SURGICAL ELECTRICITY,

AND SHORT NOTICES OF THE

PRINCIPAL DISEASES IN WHICH ELECTRICITY HAS
BEEN EMPLOYED SUCCESSFULLY.

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BIBLIOTHECA BODLEIANA

HENRY RENSHAW,
356, STRAND, LONDON.
1875.

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160. g. 62

LONDON:
SAVILL, EDWARDS AND CO., PRINTERS, CHANDOS STREET,
COVENT GARDEN.

PREFACE.

THE object of these outlines is to present to the Profession a *précis* of the leading facts in Electro-Physics and Electro-Physiology on which the theory and practice of Electro-Therapeutics are founded.

The employment of electricity in medicine and surgery has now reached that point of recognition by the profession, when no medical man can be considered a master of his art who remains in ignorance of its principles.

To many actively engaged in practice, who cannot find leisure sufficient to master a new study in all its details, it is hoped these outlines will furnish a safe and ready guide to the scientific employment of this potent agent.

To others more at leisure it will, I trust, be the means of directing their attention to a most interesting and important study. For their benefit I append, on the last page, a list of the principal authors consulted by me in the preparation of this work, all of whom may be read with advantage, but particularly the last, who for all practical purposes exhausts our present knowledge of the subject.

HUGH CAMPBELL.

38, QUEEN ANNE STREET,
CAVENDISH SQUARE.

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OUTLINES
OF
MEDICAL AND SURGICAL ELECTRICITY.

PART I.

CHAPTER I.

MAGNETISM AND ELECTRICITY.

Magnetism and electricity varieties of one fluid.

THE presence of a subtle, imponderable fluid pervading everything in nature, and influencing more or less all its operations, is made manifest to us by phenomena which, while they are clearly traceable to one ultimate cause, vary sufficiently to be classed under two distinct heads, to which the names of Magnetism and Electricity are given.

Theories of its composition.

What the ultimate composition of this all-pervading fluid is, remains an unsolved problem; various theories have been suggested to explain its nature; the one most generally received assumes it to consist of two distinct fluids, each composed of infinitesimal molecules which repel each other, while they attract the molecules of the opposite variety; perfect balance in quantity between these two fluids, produces in a body capable of becoming magnetic, the condition known as the magnetic equilibrium; in other substances, that state which is recognised as natural electricity.

Magnetic equilibrium.

Natural electricity.

When a body capable of becoming magnetic is magnetized, these two fluids which existed in it in a balanced or neutral state are separated; this separation gives to the magnet that peculiar quality termed polarity, by which it manifests two opposite kinds of magnetism termed relatively to each other the north and south poles. When a magnetic needle is so suspended that it can move without hindrance in any direction, one end always points to the north and the other to the south, and as the molecules of which the magnet is composed repel molecules of their own kind while they attract the molecules of the opposite kind, so the poles repel like poles and attract unlike poles.

Magnetic polarity.

Attraction and repulsion.

Another theory to account for magnetism has been suggested, which is that all bodies capable of becoming magnetic consist of particles each of which is itself a perfect magnet, but that these infinitesimal magnets have their poles so placed as to neutralize each other, in which condition they remain until called into activity by magnetization, which has the effect of bringing the poles of these particles round so as to lie in the same direction, and the power of the magnet or conglomeration of infinitesimal magnets thus

Theory of infinitesimal magnets.

thrown into action depends on the completeness of the coincidence produced.

Induction of active electricity.

When a substance is exposed to friction, cleavage, pressure, heat or chemical action, its natural electricity is resolved into its elements, termed negative and positive, and active electricity is induced. Negative and positive electricity, like the north and south poles of the magnet, repel their like and attract their unlike.

Negative and positive electricity.

Magnetism induced by electricity.

The passage of a current of active electricity through a bar of steel or soft iron induces magnetic qualities in these substances, which then become magnets.

Electricity induced by magnetism.

The alternate approach to and withdrawal from a permanent magnet of steel, of a coil of wire, induces currents of electricity, which are called magneto-electric or magneto-faradic currents.

From this it may be seen, that on the one hand electricity induces magnetism in bodies capable of developing it; and on the other, magnetism induces electricity, under certain conditions, in other bodies.

The term electricity first used by Dr. Gilbert.

Electricity was first made known publicly, in 1600, by Dr. Gilbert, physician to Queen Elizabeth, who first used the term electricity, which he derived from electron (amber), because, according to tradition, Thales, one of the seven wise men of Greece, first induced it by the friction of amber against dry woollen cloth.

Magnetism was known to the ancients through

Magnetism known to the ancients.

the action of the natural magnet, loadstone (iron-ore), first discovered in Magnesia, in Asia Minor, from whence it takes its name.

While magnetism, as such, exercises no appreciable influence over animal tissues, living or dead, electricity in its different forms exercises a most notable and powerful influence over them. Destruction of balance, setting free active electricity, is constantly going on in animal and vegetable life and in all processes in nature.

Currents of electricity always flowing.

There are currents of positive and negative electricity always flowing over earth and water, and in the atmosphere; these currents increase

Tidal electricity.

and subside in regular tides, and vary in quantity and variety with the seasons, and these varieties affect animal and vegetable life for good and evil; in the human subject having the most marked effect on the nervous and impressionable.

Ozone.

In the atmosphere, the action of electricity on some part of its oxygen produces ozone, a gas of such importance in the economy of our globe, that it is possible life would not exist in its absence, and it is equally probable that its presence in the atmosphere in great excess is often attended with serious detriment to animal and vegetable existence. In its due proportion in the atmosphere it is constantly and actively engaged in the work of purification, destroying all the noxious and poisonous vapours and gases which would otherwise accumulate in it.

Special qualities of electricity.

Positive electricity increases the vital forces, negative electricity diminishes them.

Active electricity exercises powers of attraction and repulsion, decomposes compounds, produces heat, light, and magnetism, and when placed in direct contact with the animal body produces sensations which, according to the amount employed, may either be mild, pleasurable and healthy, or painful, alarming and dangerous in a high degree.

CHAPTER II.

STATIC AND CURRENT ELECTRICITY.

ELECTRICITY is of two kinds—viz., Static and Dynamic or Current; both these varieties are applicable to the purposes of medicine, a variety of the latter to surgery also.

Statical electricity.

Statical electricity, called also from its method of production frictional and inductive electricity, and from Dr. Franklin, who first demonstrated its identity with lightning, Franklinism, is furnished by an instrument termed an electric machine, the first rude attempts at the construction of which were made, in 1671, by Otto von Guerike, a German. Since his time the machine has undergone many changes and improvements, and at present, in its most approved shape, consists of a disc of plate-glass in contact at portions of its circumference with two leather cushions, one on each side; rotation of the disc by means of a handle produces the friction necessary for the liberation of the electricity. When positive electricity is required, a brass chain is attached by one end to the cushions to collect their negative electricity and run it off by the other end which is connected with the ground; the positive electricity then accumulates on the glass disc, and may be drawn off on a row of hollow brass balls connected by two horizontal glass tubes and resting on glass pillars; this is called the prime conductor, and is connected with the horizontal diameter of the disc. When negative electricity is required, the chain is connected with the disc instead of the cushions, and thus removes the positive electricity, which is carried into the ground.

Appearance in the dark.

To prevent the electricity escaping into the atmosphere during its liberation by rotation of the disc, a portion of the latter is covered with oiled silk. If the machine is set in motion in a dark room, streams of fire are seen to come from beneath the oiled silk covering and disperse themselves over the plate, and if the hand be held near the prime conductor a curious undulating or streaming sensation is experienced in it, while if it be brought sufficiently near, sparks pass to it, giving rise to a sharp pungent sensation in the skin, and producing a white rash.

Smell.

A smell, half sulphurous and half phosphoric, is perceived while the machine is in action. This is due to the transformation of the ordinary oxygen in the atmosphere into allotropic oxygen or ozone. The peculiar smell which accompanies a flash of lightning is due to the same cause. Of all forms of electricity, the static exercises the most considerable powers of attraction and repulsion. This energy is greater the nearer the bodies between which they are exercised are placed. When bodies charged with the opposite electricities are brought in actual contact, the two fluids become neutralized; and during the act of neutralization the electric spark is formed, accompanied by a crackling noise. Static electricity can also be collected by means of the Leyden jar, which was invented in 1745 by Musschenbroek, of Leyden. It consists of a rather wide-mouthed glass jar, which has an inner and outer coating of tinfoil; the inner coating is connected by a brass rod, the upper portion of which passes through the stopper of the jar, and for about 2½ inches beyond it, and terminates in a brass knob; the lower portion ends in a brass chain, which rests on the bottom of the jar. The jar is charged by connecting the outer coating with the ground, which is done by holding it in the hand, while the knob which communicates with the inner coating is presented to the prime conductor of the electric machine, and from it receives positive electricity, which passes down the brass rod and collects on the inner coating of the jar. To discharge the jar a connexion must be made between the negative electricity on the outside and the positive electricity on the inside. For medical purposes, this is done by holding it in one hand and touching the portion of the body to be operated on with the brass knob; a brilliant spark is then seen, a snapping noise heard, and a shock experienced, the intensity of which depends on the size of the jar.

Formation of the electric spark.

The Leyden jar.

There are three methods of using statical electricity in the treatment of disease—viz., the electric bath, shocks from the Leyden jar, electrization by sparks.

Electro-positive and negative baths.

The electric bath may be either positive or negative. The electro-positive bath has a stimulating and restorative effect on the patient; it increases his secretions, and gives tone and force to his circulation. The electro-negative bath has a depressing effect upon the patient; it deprives his body of its normal electricity, and produces results equivalent to blood-letting.

Method of application.

The method of using the electro-positive bath is to place the patient on an insulating stool, and place the prime conductor in his hands; through it he receives into his body the positive electricity accumulating on the glass disc, while the negative electricity from the cushions is carried off by a metallic chain connected with them and the ground. To receive the full effect of the bath, the patient must continue the application for at least two hours daily. In the electro-negative bath, the patient, also insulated, receives the negative electricity from the cushions, while the positive is carried into the ground by a metallic chain connected with the glass disc.

Electrization by sparks.

Electrization by sparks is performed while the patient is in the electro-positive bath, by the application of a metallic rod or the hand to the part to be operated on. The negative electricity of the rod or hand combines with the positive electricity of the patient, and active electricity is produced with a flash of light and a snapping noise. A rapid succession of these applications produces vibrations in the superficial muscles, accompanied by a pricking, stinging sensation and redness, and white circumscribed wheals on the skin, which remain for about an hour. This method of applying electricity has been found useful in amenorrhœa, chorea, and paralysis, but is not very generally employed in these diseases.

Effects.

Shocks from the Leyden jar are produced by placing the portion of the body to be operated on in the circuit between the inner and outer coatings of the jar. The effect is in reality a shock—sudden and disagreeable; but in very obstinate cases of amenorrhœa it has restored the flow when all other forms of electricity have failed.

Shocks from the Leyden jar.

Two forms of current electricity.

Current electricity, called also dynamic electricity (electricity in motion), embraces two varieties—viz., Galvanism and Faradism. Faradism is subdivided into electro-magnetism and magneto-electricity.

Galvanism, voltaic electricity, or the continuous current, is produced by chemical action, more particularly that which attends the dissolution of metals. The *quantity* of electricity generated is in proportion to the amount of chemical action, that is, the amount of metal dissolved in a given time. The electro-motor force or *tension* is the power that enables the current to overcome all resistances which might impede its progress.

If two heterogeneous metals, such as copper and zinc, be connected by means of a conductor moistened with water, electricity is developed. The metals so situated are termed the elements, the liquid employed the exciting fluid. The real source of galvanic electricity is the chemical action going on between two heterogeneous conducting bodies. The metal which is most attacked in a galvanic circuit is called positive, and that which is less or not at all attacked, negative. All metals if properly arranged give rise to an abundant development of active electricity, and the more they differ in their characters the greater is the force, intensity, or tension of the current generated, but the most powerful combination consists of plates of carbon (non-metallic) and zinc (metallic).

Source of galvanic electricity.

A combination of two metals, or of zinc and carbon moistened or placed in a liquid, form an open circuit, which becomes a closed circuit when the two are connected independently of the fluid by a metal wire, termed the arch or conjunctive wire. This being a better conductor than the fluid permits the two opposite electricities, liberated by the chemical action going on, to travel towards each and combine; this process *continues* as long as the chemical action goes on, hence the term continuous current.

Open circuits.

Conjunctive wire or arch.

Difference between constant and continuous currents.

A constant current differs from a continuous current only in so far as that the continuity is constant, that is to say, the pair or pairs of metals are so arranged that the electric fluid is constantly generated and flows continuously.

Production of powerful galvanic currents.

A powerful galvanic current is produced by joining several pairs of heterogeneous metals in such a manner that the negative metal of the first pair is connected with the positive metal of the second, and so on till the required number of pairs is made up. This is the compound galvanic circuit which has undergone many modifications since its first invention in the form of the voltaic pile, the current formed by which is variable and unreliable, and quite unfit for therapeutic purposes; it has been superseded by the galvanic battery, of which there are many varieties.

Two currents in each galvanic pair.

In each galvanic pair there are two currents, a negative one flowing towards the positive pole, and a positive one flowing towards the negative pole. The position of these poles can be easily established by placing two copper wires in a solution of common salt or sugar, and attaching the free end of each to the poles of the battery, when bubbles of hydrogen gas will surround and arise from the end of the wire attached to the negative pole, the other or positive wire becoming at the same time black from oxidation.

The current must traverse a circuit.

In every instance the stream must traverse a circuit; that is to say, the current will not flow unless the plates or wires are in contact. This is termed a closed circuit. When the current is arrested by separation of these, the circuit is said to be open or broken.

Electricity generated wholly by action of acid on zinc.

Two liquids and one metal can produce a circuit as well as one liquid and two metals.

In a battery composed of plates of zinc and copper, the electricity is generated wholly by the chemical action of the acid on the zinc; and in both simple and compound circuits the electricity always moves in the liquid of the battery from the zinc to the copper, and out of the liquid from the copper to the zinc.

Polarization.

The deposition of hydrogen on the surface of the negative plates produces the condition in the battery which is termed polarization; in this state the heterogeneity of the plates is destroyed, and the action of the battery arrested.

Polarization prevented.

Polarization may be prevented by placing the electro-negative element in a liquid that is acted on chemically by the deposited hydrogen. To carry this out effectually two conducting liquids, separated by a porous partition, are employed, instead of one liquid only; in these batteries the evolved hydrogen, instead of being deposited on the zinc plates, enters into other combinations, and polarity is prevented.

Composition of a constant battery.

A constant battery is one in which polarity is obviated in the manner just described. Each battery consists of five substances. 1st. The negative pole formed by the metal, the destruction of which by chemical action generates the elec-

Negative pole. tricity. This metal is almost invariably zinc. 2nd. The chemical, usually an acid, which decomposes the metal. 3rd. The porous partition or diaphragm. 4th. The material employed to arrest the evolved hydrogen, and prevent the polarization of the metallic plate; this is generally a solution of sulphate of copper. 5th. The collector of electricity, which is not acted upon by the liquids, and which remains unchanged. This is usually made of copper or carbon, and forms the positive pole of the battery. Any number of these single batteries may be joined together to meet the strength or purpose required. The current which flows during the closed circuit is termed the primitive current. If two points be connected by an additional conductor, a portion of the current is withdrawn. This is termed the derived current, the tension of which is much weaker than the original or primitive current.

Positive pole.

Primitive current.

Derived current.

Use of galvanic current.

The constant galvanic current is employed in the treatment of many internal diseases, the absorption of effused fluids, the decussion of tumours (electrolysis), the removal of malignant growths (galvano-cautery), and in many other surgical diseases.

Varieties of constant batteries.

Numerous varieties of constant batteries exist, but for therapeutical purposes it is necessary to notice only those which can be employed in practice with the certainty of not disappointing the operator. These may be classed under two heads—the large battery for the consulting-room, too ponderous to be carried about, and the portable battery for outdoor practice.

Consulting-room batteries.

The consulting-room battery, which surpasses all others in certainty and steadiness of action, is the Daniell-Muirhead, a modification of the original Daniell's battery. The chemical changes which go on in this battery are so retarded by the employment of ordinary water for the zinc plates, and a solution of sulphate of copper for the copper plates, that polarization is reduced to a minimum, and the intensity of the current is maintained for months without any perceptible diminution, even if used constantly. The author's battery of this description has been in operation for the last four years, and although used daily, often for many hours with very slight intermissions, it has never disappointed him. The porous vases and plates have been renewed once since the battery was constructed, but this was more a measure of precaution than absolute necessity, as there was every reason to believe they would have lasted somewhat longer. The exciting fluids require to be renewed about once a month.

Daniell-Muirhead battery.

The author's battery.

Therapeutical effects of large batteries.

The therapeutical effects of large batteries of this description are more reliable than those of the smaller and more portable kind, the action is steadier and more regular, the dose administered more reliable and constant, as the amount generated is always the same, while in the portable battery local currents are very apt to form after a little use, which embarrass the flow of the main current, and leave the operator unable to determine with certainty whether the dose he is administering to-day, say of 15 cells, is equal in intensity to the dose from the same number of cells which he administered at his previous visit.

Portable batteries.

The best portable batteries are Leclanché's, modified by Beetz, of Munich, Gaiffe's chloride of silver battery, Stohrer's chloride of silver battery, Foveaux's modification of Smee's, Kidder's carbon battery, Stohrer's carbon battery, and Mayer and Meltzer's carbon battery. Of these the four last are in every way the best as far as portability, intensity, and reliability are concerned. The elements in Foveaux's battery are zinc and platinized silver; in the others zinc and carbon. In all, the exciting fluid is dilute sulphuric acid. As the carbon batteries are less liable to polarization than the platinized silver, and the current of the latter often diminishes in intensity during its application, unless the acid has been very recently renewed, I am disposed to rely more confidently on the carbon batteries for general use. All these batteries are furnished with simple arrangements for increasing or diminishing the number of cells in action, and for reversing the current without removing the electrodes from the patient. Mayer and Meltzer's carbon battery has the advantage over Stohrer's in being more easily replenished with the dilute acid, and in being closed in, so that no hydrogen escapes when in action.

Carbon batteries.

Electrolysis.

Any of these batteries may be advantageously employed for electrolysis. Batteries for galvano-cautery require a special arrangement, which will be described in the notice of electro-surgery.

The rheophores

The electrodes.

Anodes and cathodes.

The wires which conduct the current from the battery, to the individual to be operated upon, are called rheophores, at the free extremity of each of which is the electrode, or instrument for application to the body. The electrode attached to the positive pole is called the anode; that attached to the negative, the cathode. The electrodes should always be furnished with handles of some non-conducting substance, as ivory, ebony, or vulcanite. The part applied to the body should be covered with moistened sponge to prevent the unpleasant effects of the metal on the surface.

Action of the current in the anodes.

The metal electrodes must be kept scrupulously clean to insure the steady transmission of the current. The anode especially requires attention, as its surface becomes quickly oxidized and chlorinated during use, and then ceases to be a reliable conductor. The greenish-blue colour which stains the sponge of an unclean anode shows the chemical changes which dissolved the copper.

Some electro-therapeutists use different coloured silk coverings for the rheophores, as green for the negative, and red for the positive; but this arrangement is embarrassing and useless where a current reverser is employed.

All the elements of a battery must be of uniform strength.

In dealing with galvanic batteries, the operator must bear in mind that all the elements employed require to be of uniform strength; the weakness of one cell reduces the power of the whole. The current can pass through any cell, only by giving rise to the same amount of decomposition that was required to generate it, in the cells from whence it came; hence care must be taken to keep both elements and exciting fluid of uniform strength. The quantity and approximate intensity of the current can be ascertained by the galvanometer. This in its simplest form, consists of a magnetic needle placed between the two arms of the conducting wire of the battery bent back upon itself. As long as no current passes through the wire the needle is at rest, but the moment the circuit is closed the needle is deflected, and the angle of deflection is a rough estimate of the intensity. For therapeutical purposes this is usually sufficient, but for delicate physiological inquiries Schweigger's Multiplier, or Sir William Thomson's Quadrant Electrometer, is required.

Quantity and intensity ascertained by the galvanometer.

Schweigger's Multiplier and Thomson's Quadrant Electrometer.

Quantity.

The quantity of electricity given off by a galvanic battery in action, is in exact proportion to the surface of the elements, and the degree of affinity existing between the various component parts.

Intensity.

The intensity or tension of the current, is the power it may possess to overcome any resistance which would impede its progress.

Galvano-cautery.

When quantity alone is required, as in the batteries employed for galvano-cautery, a large surface of metallic plates in a few cells are employed, and the chemical action is increased by using a strong acid solution. When intensity is the object to be attained, as in galvanization, or for electrolysis, a considerable number of cells of rather small size are required, with a weak acid solution giving rise to feeble chemical action.

Galvanization.

When a battery acts irregularly, or ceases altogether, a careful examination should be made of all its parts, beginning first with the elements; these should be gone over in detail to ascertain if the metals are worn out, polarized, displaced, or disconnected. If they are in a satisfactory condition, the exciting fluid and its containing cells require examination; the fluid may be neutralized by chemical decomposition and require changing, or evaporation of the watery portion of it may have been excessive, and the residue may require a further dilution. If all these parts are in good order, the wires or electrodes are at fault, and to them attention must be directed.

Irregular action of galvanic batteries.

ELECTRO-MAGNETISM, or the induced or interrupted current, differs in many material points, both physical and therapeutic, from galvanism. Faraday discovered, in 1831, that when a galvanic current is passed through any conductor, it *induces* a current in the opposite direction in a second conductor situated parallel to the first; these currents are instantaneous, but can be induced in regular succession by closing and breaking the galvanic current, as it is at the moments of closing and breaking that the secondary currents are generated. The intensity of these

Faradism.

Increase of intensity.

instantaneous currents may be increased, first by employing two copper wires of considerable length, covered with silk or gutta-percha, and coiled round a hollow cylinder; secondly, by introducing into the cavity of the cylinder thus covered, pieces of soft iron which become magnetic, under the influence of the galvanic current, and produce other electric currents in the two coiled wires. How this takes place science cannot yet explain, the most perplexing point in the mystery being that it is not necessary, in exercising its influence, that the soft iron centre piece or core should be very close to the coiled wires. The currents induced in the magnetism of the soft iron are as instantaneous as those induced by the galvanic current, and like them only exist at the moment of closing and breaking the circuit.

Magnetic currents.

Difference between electro-magnetic and galvanic currents.

The electro-magnetic current differs from the galvanic in being instantaneous, and in the important fact that while the galvanic current always flows in one direction, the electro-magnetic moves alternately in different directions. This can be easily seen, by placing the poles in a solution of iodide of potass and starch, when the blue stain of the disengaged iodine will appear at each extremity.

Rheotome.

To close and break the circuit, so as to keep up a constant succession of instantaneous currents, an ingenious instrument is employed, to which the name of rheotome is given; this as at present used, consists of a small stem of soft iron placed under or above the induction coil; one end of this stem is fixed to a piece of metal outside the coil, while the other end, which is moveable, is put in motion by the temporary magnetism of the soft iron in the centre of the coil. A platinum spring is soldered to the lower surface of the hammer and rests upon a piece of copper, likewise covered with platinum. The metal stem communicates with one of the poles of the battery, and the piece of copper covered with platinum with the other pole. The circuit is closed each time these come in contact; this contact magnetizes the soft iron in the centre of the coil and attracts the moveable end of the hammer, which withdraws the two parts from each other and breaks the circuit; this de-magnetizes the central soft iron, and the hammer drops into its former position; the circuit being again closed, the soft iron regains its magnetism, the hammer is again attracted, the circuit again broken, and these alternate conditions obtain as long as the battery is in action. At each interruption a spark of a beautiful amethyst colour passes between the two pieces of platinum; this in course of time oxidizes the surface of the metal, which must occasionally be cleaned. This instrument is the invention of Dr. Neef, of Frankfort.

Electric spark.

Varieties of induction apparatuses.

A great variety of electro-magnetic apparatuses exist, varying considerably in power, portability, reliability, and simplicity, all matters of great importance in their employment. The principal are—

Duchenne's Volta-Faradic, which requires a pair of cells of Bunsen's battery.

Legendre's, which must be daily charged with nitric acid, and is easily spoiled.

Gaiffe's bisulphate of mercury,

Ditto, chloride of silver, both unreliable in action.

Stöhrer's single and double-celled Faradic apparatuses, which are put in action by zinc and carbon plates excited by chromic and sulphuric acids. Most excellent batteries, but somewhat clumsy in arrangement.

Weiss's Faradic Machine, in which zinc and carbon plates excited by a solution of bichromate of potass and dilute sulphuric acid are used. This is an excellent battery, very reliable and easily managed.

Mayer and Meltzer's Induction Apparatus; the battery of this, like the last, is composed of zinc and carbon plates excited in the same manner. It is by far the most desirable of all the induction instruments I am acquainted with, as it contains in a very small compass all the power which can be required for medical purposes; the primary and secondary currents can be used without changing the conducting wires, and the index enables the operator to graduate the strength of the current in the most delicate manner.

Apparatus for magneto-electricity.

MAGNETO-ELECTRICITY (*Magneto-Faradism*).—If the pole of an ordinary magnet be approached to one end of a copper wire covered with silk or gutta-percha, and coiled round a wooden reel, an instantaneous current is produced in the wire, and when the magnet is withdrawn another instantaneous current is produced in the wire, moving in a direction contrary to the first current. To produce a succession of these currents, the magnet must be continually approached to and withdrawn from the coil of wires. In order to do this with rapidity, the permanent magnet is not made to act immediately on the wires, but an armature of soft iron, shaped like a horseshoe, is surrounded by them and set in rotation before the two poles of the magnet, by means of a wheel attached to an endless cord; by each turn of the wheel the two branches of the armature are made to pass before the poles of the magnet; at each passage there is magnetization and de-magnetization of the soft iron, and an electric current is produced at the moment the armature is approached to and when it is withdrawn from the magnet. The intensity of this current depends upon the power of the magnet, the number of convolutions and diameter of the wire coiled round the armature of soft iron, on the distance of the armature from the poles of the magnet, and on the velocity with which the wheel is turned.

Effects of the magneto-electric current.

The magneto-electric current is seldom used in electro-therapeutics; it is rough and disagreeable in action, and unreliable in its effects; owing to its cheapness it has been much used by the public, and its employment largely and indiscriminately, has been productive of much mischief both to the individuals using it and to the cause of curative electricity.

CHAPTER III.

ANIMAL ELECTRICITY.

Animal electricity.

CURRENTS of electricity exist in all portions of the animal body; they are greatest wherever nutrition is most active, and are easily demonstrable in the muscles and nerves, as these tissues abound in them.

Animal electricity and galvanism identical in character.

Animal electricity is identical in its character with that form of dynamic electricity which is called galvanism; like it, the phenomena of electrolysis can be produced by it and the needle deflected; but unlike it, it is not the result of contact between heterogeneous substances, as all the animal tissues are, from an electrical point of view, homogeneous.

Liberation of electricity in the animal tissues.

The liberation of electricity in the animal tissues is the result of those disturbances of equilibrium in their molecules, which occur in the never-ceasing processes of waste and repair which are going on. The currents thus produced have for the most part only local circuits, and are subordinate to the life of the animal, as they cease soon after death. Electricity collected from living animal tissues is much feebler in intensity than that which actually exists in the nervous and muscular currents, as these latter are in the condition of closed circuits, and every current taken from them is only a *derived* current.

The current of a whole limb is the resultant of the partial currents engendered in the various tissues of that limb.

Theories to account for animal electricity.

The explanations of the phenomena of animal electricity are all purely theoretical; the theory which is most widely accepted is that of Du Bois-Reymond, who supposes that muscles and nerves consist of electric molecules which have one positive equatorial zone and two negative polar zones, whose axes are parallel to each other; that is, two molecules make one molecule. This is called the peripolar arrangement. Each molecule of the nerve or muscle manifests the same phenomena as the whole nerve or muscle. These peripolar molecules are enclosed by a moist covering.

Pile-like arrangement.

Du Bois-Reymond further supposes that each peripolar molecule may be divided into a group of dipolar molecules, where the positive hemispheres are turned towards each other, without changing their electrical properties. This is called the dipolar arrangement. If a number of such molecules are brought under the influence of a galvanic current, their positive zones will turn toward the negative pole and the negative toward the positive, one of the molecules turning 180° on its axis. From its resemblance to the voltaic pile, it is called the pile-like arrangement. These phenomena have been demonstrated on molecules made of copper and zinc.

Du Bois-Reymond's conclusion.

From these experiments Du Bois-Reymond concluded, first, that the nerve is always in the condition of a closed circuit, since electric currents are produced by the connexions of layers surrounding the molecule with their moist envelopes; and, secondly, that a current obtained from an animal, as indicated by the galvanometer, is only a small portion of the entire current.

Peri-polar arrangement.

The electric currents in the nerves show, in many instances, such sudden variations both of intensity and direction that there seems to be no theory which will satisfactorily explain the phenomena except that of Du Bois-Reymond already alluded to, to which he has given the name of the peri-polar arrangement.

Nervous currents may be weakened or destroyed.

The nervous current may be weakened, diverted, or totally destroyed by repeated powerful electrical discharges; most substances which have a decided chemical action upon nervous tissue, as ether, alcohol, and mineral acids, produce the same results; so also do strychnia, prussic acid, and opium; arsenious acid, except in a highly concentrated solution, has no effect in arresting the nerve current, and even then only to a very slight and feeble degree. Extremes of heat and cold, desiccation, and imbibition of a large quantity of water, are likewise deleterious to the nervous current.

Muscular current.

The muscular current differs only from the nervous in being stronger; its direction is the same, and its variations in intensity and direction are as sudden and extensive as in the nervous current, and like it can only be accounted for by assuming corresponding changes of position in the molecules of the muscle of exactly the same description as those which have been already stated as supposed to occur in the nerve molecules. The muscular current is inherent in the living and excitable tissue only; it disappears after death, but more rapidly in warm than cold-blooded animals, and the difference is often very marked; very few warm-blooded animals retain it an hour after death, while a frog's limb, kept at a low temperature, has given evidence of its presence for nearly a month after the animal's destruction.

Muscular current disappears after death.

The local application of poisons and of substances which have a marked chemical action on vitalized tissues, act more powerfully in arresting the muscular currents than when introduced into the general system.

Each point of a longitudinal section of a living muscle is positive in respect to each point of a transverse section, and this law not only holds good in the entire muscle, but even in a single primitive bundle of it.

Cutaneous electric currents.

Electric currents in the human skin exist in a sufficiently marked manner to be ascertained with certainty, although they are liable to be confounded with other currents not truly animal, which traverse the surface of the body. Unequally heating the corresponding finger of each hand will produce a thermo-electric current; a finger at the temperature of 32° F. is strongly positive to one at 90° or 98°, while a finger at 60° is feebly positive to one at 80°, and strongly so to one at 120°; these thermic currents are quite distinct from currents of animal electricity.

Du Bois-Reymond's experiments.

The results obtained in Du Bois-Reymond's experiments on cutaneous currents in man are very curious and interesting. Any two fingers at the same temperature, simultaneously immersed in the testing vessels, did not appear to possess complete homogeneity; for after some irregular oscillations of the needle a feeble constant current was observed to flow in the same direction for months consecutively. The direction and intensity of this current varies considerably with the individual. Sometimes the current which has been flowing steadily for months in one direction will suddenly, without any appreciable cause, become reversed, and continue so for a lengthened period. This electric current is called the individual current of the finger.

If, instead of immersing the two fingers simultaneously, they are placed in the testing vessels one after the other, the finger last immersed is strongly positive to the first, and continues so if one finger be more deeply immersed than the other, or its position altered; but if they remain at the same depth and quiescent, this current gives place to the individual current.

If, instead of using two fingers only in these experiments, the two hands, feet, or elbows are immersed, the results are the same. Du Bois-Reymond's experiments prove satisfactorily that the palm of the hand is strongly negative to its back, that the whole hand is negative to the elbow and the chest, that the elbow is feebly positive to the chest, that the sole of the foot is strongly negative to the back of the foot, and the whole foot negative to the chest. The whole hand is generally negative to the foot, but sometimes the reverse obtains at the commencement of the experiment. All these currents are strong and constant, and totally distinct from thermic currents.

In all inquiries of this nature great care is required to prevent false conclusions; electric currents from ordinary chemical action are constantly traversing the surface of the body, but they must not be confounded with the vital phenomena of true animal electricity.

CHAPTER IV.

ELECTRO-PHYSIOLOGY.

Effect of the galvanic current on the nervous current.

THE intensity of the nervous current is materially affected by the action of a galvanic current upon it. If the galvanic current move in the same or positive direction the intensity is increased, if in the opposite or negative direction it is diminished. This altered state of the nervous current is termed the electrotonic state; it commences as soon as the circuit of the battery is closed, remains unchanged all the time the battery current circulates in the nerve, and disappears the moment the circuit is opened. It is greater when the galvanic current flows lengthwise than when it flows across the nerve.

Electrotonos.

The condition of the nerve thus produced, is not merely the effect of the battery current, but is an actual alteration of the electric properties possessed by itself; for if the nerve current be arrested by tightly drawing a wet thread across it, so as to completely separate the nervous matter, the battery current flows on unimpeded, but the electrotonic condition of the nerve is at once arrested.

When a nerve is in a state of electrotonos, it is in a condition of diminished irritability at the positive pole, and of increased irritability at the negative; the former is termed anelectrotonos, the latter catelectrotonos. At some point between the poles the irritability of the nerve remains unchanged. This point varies with the strength of the current; when this is weak the point is near the positive pole, when strong, near the negative; so that in a very weak current nearly all the nerve which is enclosed between the poles is in a state of catelectrotonos, and when the current is strong, of anelectrotonos. These conditions are present not only in the intra-polar portion of the nerve, but extend into the extra-polar portions.

Catelectrotonos and anelectrotonos.

The catelectrotonic condition is produced in the nerve immediately after closing the circuit, but the anelectrotonic state developes gradually after such closure. The portion of the nerve which is in the anelectrotonic state has its conductibility diminished, while that which is in the catelectrotonic condition has it increased.

The irritation of a nerve when a galvanic current is passing through it is not uniform: at the closing of the current it is near the negative pole, and at the opening of it near the positive pole.

Cessation of Electrotonos.

When galvanic action ceases in a nerve, its electrotonic state ceases, but other conditions remain; its irritability is increased at both poles, and in the extra-polar region at the negative end, and this continues for some time after the current is broken.

Electrotonos will frequently restore the irritability of a nerve after it has been lost by disease or injury.

Meaning of irritability in a nerve.

By irritability in a nerve is meant that inherent power it possesses of responding to stimuli, and which may be impaired or destroyed by interruption of the circulation, by pressure, by injuries, and by extremes of temperature. The irritability of a nerve is increased by moderate and diminished by very rapid electric stimulation. The laws of electrotonos and the peculiar action of the poles are modified by the direction of the current.

Ascending and descending currents.

The current is said to be ascending, inverse or centripetal, when the negative electrode is towards the centre and the positive at a more peripheral part. The terms descending, direct or centrifugal, are applied to the current when the positive pole is as near the centre as practicable, and the negative some distance from it.

Effects of ascending and descending currents.

The ascending current increases excitability.

The descending diminishes excitability.

The ascending current increases reflex action.

The descending current decreases reflex action.

The ascending current acts most powerfully on the sensitive nerves.

The descending current acts most powerfully on the motor nerves.

The ascending current, through the spinal cord, acts upon the motor nerves by direct action.

The descending current, through the spinal cord, acts upon the motor nerves by reflex action.

All these laws have been fully established by electro-physiological experiments.

Effect of continuous electricity on the living human brain.

The brain in the living man is easily affected by a continuous current directed to the auriculo-maxillary fossa, the mastoid process, and the occipital region. Certain conditions of the blood-vessels in these parts favour the transmission—a large vein connecting the posterior auricular veins with the transverse sinus passes through the mastoid foramen, as does also the posterior meningeal artery; while in the occipital region the deep cervical vein and the transverse sinus are connected by a vein passing through the posterior condyloid foramen.

Transverse currents.

If the current flow transversely through either the anterior or posterior portions of the head, there is rarely giddiness, but if one pole be placed in the auriculo-maxillary fossa and the other on any part of the body, it is produced at once, provided the power employed has sufficient tension.

A current sent through the ears, so as to traverse the base of the brain transversely, produces flashes of light and giddiness.

If the anode be divided into two parts, and one part be put into each auriculo-maxillary fossa, while the undivided cathode is placed on the nape of the neck, no vertigo takes place; but if one branch of the divided anode be taken away, vertigo is at once produced, even if a milder current be employed.

Transverse currents with voltaic alternatives.

When a current is flowing transversely through the head and voltaic alternatives are employed, peculiar movements in the eyes take place. If the anode be in the right mastoid fossa and the cathode in the left, both eyes are jerked towards the left, and remain fixed in that position if the alternatives are suspended and the current be moderately strong. The reverse of this occurs, when the anode and cathode exchange positions.

Galvanism of the spinal cord.

The spinal cord can be affected during life by moderately powerful galvanic currents, applied externally to the spinal column. Proofs of its penetration to the substance of the cord, will be found in the muscular contractions in the limbs and the sensations of tingling and heat, felt in the feet when the current is applied. For example, the muscles which receive their nervous supply from the sciatic nerve, can be easily thrown into powerful spasms, if one pole of the battery be placed at the first dorsal vertebra, and the other on the spinous processes of the second and third lumbar; and the contractions can be considerably increased by breaking and closing the circuit, and by voltaic alternatives.

Impossibility of galvanizing the sympathetic alone.

From its position and anatomical relations it is impossible to galvanize the sympathetic *per se.*

Other important nerves included in the circuit.

If one electrode be placed in the auriculo-maxillary fossa on one side, and the other on the transverse process of the sixth or seventh cervical vertebra of the opposite side, the base of the brain, the cervical portion of the spinal cord, and the upper cervical ganglia are all embraced in the circuit.

If one electrode be placed in the auriculo-maxillary fossa, and the other in the manubrium sterni, at the inner edge of the sterno-mastoid muscle, the upper and lower cervical ganglia, the pneumogastric, the depressor, the laryngeal, and the descending branch of the hypoglossus nerves are all included in the circuit.

Symptoms induced by galvanizing the sympathetic, &c.

The symptoms produced on the healthy subject, by passing a continuous current, through the various nervous tracts, embraced in these two methods of application, are drowsiness and vertigo; instantaneous dilatation of the pupil, passing gradually into constriction; dilatation of the retinal vessels at first, followed by gradual contraction, continuing for some time after the current is withdrawn; decrease of tension and pressure, in the arteries, notably perceptible in the carotids and radial arteries; diminution in the number of beats in the pulse; the curves of the carotids are much altered, as shown by the sphygmograph, the ascending line deviates obliquely to the right side, and the pointed summit gives place to a horizontal plane. Contractions of the muscles of one or both of the upper extremities are produced if the electrodes are applied in the first of the two methods stated above; these are the *deplegic* contractions of Remak, and are believed to arise from irritation of the superior cervical ganglion. Application of the current in the second manner produces a general feeling of warmth in the whole body, accompanied by gentle perspiration, rather more marked on the side to which the upper electrode is applied. This condition is produced by the action of the current on the depressor nerve.

Galvanic action on the organs of sight.

If one pole of a galvanic battery be placed on the closed eyelid (well moistened), and the other at the nape of the neck, the current is conducted direct to the optic nerve, and various effects are produced in different individuals. A stream of light is seen, the colour of which varies in different persons, but is always the same in the same individual. Each pole has its own peculiar colour, and that colour which is special to the pole nearest the eye, is the one which prevails. The colours may be yellow, lilac, red, blue, or pink. On closing the circuit, the colours of both poles appear arranged as a central disc with a halo; the central disc, which is the more intense, and lasts longer, is produced by the pole on the eyelid. The halo, which is pale, and disappears more rapidly than the disc, is produced by the pole on the nape of the neck. When the circuit remains closed, the light steadily diminishes, and at last disappears, but resumes a momentary brilliance when the circuit is broken. The eyes, from the large amount of fluid they contain, are excellent conductors of electricity, so that these phenomena are most probably due, to direct transmission of the electric molecules to the retina itself.

Colours of the light seen.

Disc and halo.

The eyes good conductors.

Effects of Faradization.

Faradization affects the retina to some extent, but as the current intermits so does the light, which usually appears in a succession of light blue flashes, corresponding in point of time with the intermission. The magneto-electric current has more marked effect in producing these phenomena, than the electro-magnetic.

Galvanization of the organ of smell.

The olfactory nerve can be excited by a continuous current, but it requires to be of such high tension, that experiments in this direction are not very trustworthy, for the giddiness, dazzling flashes of light, and faintness produced, obscure considerably the powers of observation on the part of the subject.

Galvanization of the organs of hearing.

The auditory nerve is easily affected by all forms of electricity. Ritter experimented on himself with a continuous current. When both ears were placed in the circuit he experienced a smart shock to start with, and then heard the sound $\overline{G}$, which continued while the current passed, and became higher when the intensity was increased. When the current was inverted, the sound was lower than $\overline{G}$, and decreased as the intensity increased. Althaus, on the other hand, has experimented with all sorts and directions of currents, and compared the sounds produced by the galvanic and faradic excitation of the auditory nerve, with that given by the tuning-fork of the present Philharmonic pitch, and he has always found the sound produced as near as possible to $\overline{A}$. He has never found that alteration in the direction of the current, or increase in its intensity, has

Althaus' experiments.

affected the pitch, although it has increased the intensity of the tone.

Brenner's experiments.

Brenner's experiments with the continuous current show the normal reaction of the auditory nerve. At the negative pole the nerve responds with sounds when the circuit is closed, and during a portion of the period it remains closed, while at the positive pole the nerve responds only on opening the circuit. The sounds thus produced vary in character and intensity, according to the peculiarities of the individual and the intensity of the current. The most frequent sound heard is bell-like, which when fully developed becomes a clear tone, the pitch of which, while it varies with the person, may be musically determined. When the intensity of the current is increased, some people perceive a regular scale of auditive sensations, proceeding through humming, hissing, rolling, whistling, to ringing. An increase in the intensity of the current raises the pitch when the nerve is affected by the negative pole, and lowers it when it is under the influence of the positive.

Most frequent sounds induced.

Faradism of the membrana tympani and its muscle.

The membrana tympani can be acted on by the faradic current, and phenomena produced differing from those which occur, when the auditory nerve is influenced by the continuous current. If the current have much tension, pain is produced, and sounds resembling the buzzing of a fly on a pane of glass, or the distant blowing of a trumpet; these are accompanied by a slight metallic taste and increase of saliva, from excitement of the chorda tympani, both in its trunk and in those fibres which enter the submaxillary ganglion.

The tensor tympani muscle contracts under the influence of the faradic current, and retracts the membrana tympani.

Effects of electricity on the organ of taste.

The faradic current gives rise to no sensation of taste when applied to the tongue, although it causes pain and muscular contractions. Frictional electricity gives rise to a well-defined sensation of taste, with a flash of light, and pain and vibratory motion in the tongue. The galvanic current affects the tongue in much the same manner. If a chain be formed of several individuals, one touching with his finger the tongue of the next person, and so on, while each of the two who form the extremities of the chain, takes hold of one of the poles of a battery of moderate power, every person in the chain has a decided feeling of taste. The sensation of taste produced by galvanism is generally of an acidulous or metallic character, and may be induced without direct application to the tongue. If either pole of the battery be applied to the nape of the neck, and the other to any portion of the spinal column, a coppery taste will be experienced in the mouth, often accompanied with flashes of light, which the patient will frequently describe as not being in the eyes, but in the back of the head.

Galvanic saturation.

That condition of system to which Althaus, (who was the first to notice it) has given the name of galvanic saturation, and which seems to proceed from too prolonged galvanic applications, is always accompanied by a persistent metallic taste.

Galvanism of the motor nerves and muscles.

A moderate continuous current, applied to a motor nerve, causes the muscles supplied by it, to contract at the closing of the circuit only. If the negative pole be applied to the nerve, and the positive to the muscle, the contraction is more powerful, than when the positions are reversed. The longer the applications are continued, the more powerful are the contractions, when the circuit (having been broken) is instantly closed again. If a portion of the nervous centre is included in the circuit, as well as the motor nerve and muscle, the muscular contractions are more powerful; and if the intensity of the current be increased, the contractions take place at the breaking, as well as at the opening of the circuit. If the intensity be still further increased, the contractions continue during the whole time the current flows, and after some time, become tetanic. Reversing the direction of the current without removing the electrodes, causes more powerful contractions than opening or closing the current. If the current be interrupted slowly, the contractions are clonic; if rapidly, they are tonic.

Faradism of the muscles.

A muscle subjected to the influence of a faradic current contracts with vigour, only at the points where the electrodes are placed; but if the current be applied through the nerve, contractions are produced in all the muscles supplied by it. Healthy muscles contract more readily under the application of the faradic current than of the interrupted galvanic current.

Electro-muscular contractility and sensibility.

The susceptibility of a muscle, to contract under the influence of the electric current, is termed *electro-muscular contractility*; the sensation accompanying the contraction is termed *electro-muscular sensibility*; both these conditions vary in different individuals, and in different parts of the body in the same individual, and are greatly modified by disease.

Modifications.

The anatomical position of the muscles, the distribution and number of the sensitive nerves, and the thickness of the skin and its underlying layer of adipose tissue, give rise to various modifications of both these states.

Muscular contractions and increase of temperature.

The muscular contractions produced by the electric current, give rise to increased temperature, the rate and extent of which, depend on the energy of the contractions, and the length of time the applications have been employed. When the faradic current is used, the temperature is for the first three minutes, slightly depressed, owing to the contraction of the blood-vessels, but after that period, it begins to rise for about two minutes, when it reaches its maximum. In many cases this increase is so marked as to be appreciated, not only by the patient, but by the operator, and the bulk of the muscles is so much increased, that the fore-arm has been known to gain, from a quarter to half an inch in circumference, and the thigh from a half to a whole inch.

Action on organic muscular fibre.

Electricity applied to an involuntary muscle affects it in a different manner, to a voluntary muscle. In the latter case, the contractions come on at once, are confined to the portion within the circuit, and pass off quickly when the action ceases. In the former, the contractions are not excited directly the current is applied, but when they do appear, they continue for some time after it is withdrawn, and extend beyond the portion included in the circuit. The iris is the only exception to this law; its contractile fibre-cells follow the same rule as the voluntary muscles, and the pupil can be contracted or dilated, according as the current acts on its constrictor or dilator muscle.

The iris.

Alimentary canal.

Both the continuous and interrupted currents act speedily and powerfully on the fibre-cells of the alimentary canal, particularly those of the small intestines.

The uterus.

The uterus, gravid or non-gravid, contracts under the influence of either continuous or interrupted current.

Œsophagus, stomach, &c.

Electrization of the œsophagus, produces contraction of both the longitudinal and circular fibres; of the stomach, shortening of the longitudinal and transverse fibres, the direction of the movement being from the cardiac to the pyloric end; of the intestines, peristaltic movements; of the gall-bladder, discharges of bile into the duodenum; of the ureters, contractions from the kidneys to the bladder. The bladder, vas deferens, epididymis, and tunica vaginalis contract with energy under the influence of elec-

Bladder, &c.

tricity, and it is worth noting, that no matter in what direction the current flows, the contractions induced, in all instances correspond with the physiological purposes of the organ.

Effect on the heart and arteries.

During life the heart may be reached through the cervical sympathetic, and pneumogastric with the galvanic current; after death, rhythmical contraction, especially marked on the right side, can be produced by the faradic current.

No contractile effect on the aorta.

The smaller arteries are very readily affected by electricity, the larger less so, and the aorta not at all; this arises from the fact that the smaller vessels are largely endowed with contractile fibre-cells, which are less plenty in the larger arteries, and almost entirely absent in the aorta. The descending galvanic current dilates the blood-vessels, the ascending contracts them. The faradic current, diminishes the circulation in a part, by contracting the arterioles, and if powerful enough, will entirely suspend it. When the current is withdrawn, the vessels become dilated and the local supply of blood increased.

The ascending current contracts; the descending dilates.

Faradic current.

Action on the blood.

The action of the galvanic current upon the blood in the living body is to coagulate it; the coagula formed in the veins are less firm than the arterial ones; coagulation occurs at both poles; the negative clot is red, soft and pulpy, the positive black, hard, and small.

Effect on nutrition.

The direct physical and chemical action of electricity, materially influences nutrition. Continuous centrifugal currents, lessen the excretion of urea, while continuous centripetal ones increase it, without increasing the quantity of urine.

Endosmosis and exosmosis.

The continuous current induces important modifications in the laws of endosmosis and exosmosis; the interrupted, by the muscular contractions it induces, and consequent increase of temperature, causes increased absorption of oxygen, and promotes important tissue changes.

Difference in powers of conduction in the body.

The different parts of the body vary considerably in their power of conducting the current, as the degree of resistance depends on their structure; the more fluid is contained in a tissue, the better it conducts; the hair, nails, epidermis, and bones, conduct badly, but all the soft parts conduct well, and taking the body as a whole, its powers of conduction are about fifteen per cent. greater than water, but infinitely less than that of most metals. When the current is applied over the whole surface of the body, with moistened electrodes, it passes through all the superficial and many of the deep-seated organs, muscles, and nerves.

CHAPTER V.

GENERAL EFFECTS OF ELECTRICITY ON THE HUMAN BODY, AND DIFFERENCES IN THE THERAPEUTICAL ACTIONS OF THE GALVANIC AND FARADIC CURRENTS.

Therapeutical effects.

THE most marked effects of electricity when employed as a therapeutical agent are alterative, stimulant, and tonic. It gradually improves nutrition and restores to a healthy standard, perverted and exhausted functions; the strength already possessed by the patient is not only stimulated, and supported, but permanently increased, and as a consequence, there is a greater capacity for mental and bodily labour.

Comparison with other remedies.

On comparison with medicines it will be found to produce the leading effects of iron, quinine, phosphorus, strychnine, and the nervine and blood tonics generally.

General application.

The full effect of electricity in the body is best shown in its general application over the whole surface; when so applied it improves the various operations of digestion; it also directly affects the brain and sympathetic system.

Franklinism.

Static electricity, or franklinism, is a powerful stimulant of the sentient nerves; in some forms of anæsthesia, it has succeeded after the constant and interrupted currents have failed, but generally speaking, it is rarely employed as a therapeutical agent.

Therapeutical distinctions in the effects of galvanism and faradism.

The difference from a therapeutical point of view between the galvanic and faradic currents, is of considerable importance, and merits special attention.

The galvanic current has a much greater power of overcoming resistance than the faradic. It can reach deep-seated tissues, and traverse large nerve trunks and branches, and act on the brain, spinal cord, and sympathetic ganglia.

Galvanism alone produces electrotonos.

The galvanic current alone produces the phenomena of electrotonos, on which so much depends in restoring molecular equilibrium in a nerve; it is thus superior to the faradic in the treatment of neuralgias, atrophied muscles, and rheumatic affections. Its catalytic influence over the vaso-motor system of nerves, promotes absorption, and insures the removal into the general circulation of effusions, so that its employment is indicated in dropsy of the joints, rheumatic gout, &c. Its catalytic effects are also of service, in tremor and spasm from inflammation of the brain, and in paralysis of the bladder, rectum and lower extremities, from inflammation of the cord.

The galvanic current applied intermittently, and by voltaic alternatives, is a powerful stimulant of all parts of the nervous system, and by its effects on the motor nerves, can frequently induce muscular contractions in paralysed limbs, when the faradic current has failed.

The galvanic current produces electrolytic, endosmotic, and thermal effects, which enable it to remove by absorption, or by the cautery, morbid growths of almost every description.

Faradism has greater influence over muscular tissue.

On the other hand, the faradic current, by its rapid interruptions, produces greater mechanical effects than the galvanic; by stimulating the muscles to contract, it promotes the oxidation of the contractile tissues, causes a freer supply of arterial blood to them, and thus induces chemical and vital changes in them, which augment their nutrition.

The faradic current induces physiological activity in impaired motor nerves and muscles, by rearranging their molecular equilibrium.

Effects upon contractile fibre-cells.

The faradic current has a more stimulating effect than the galvanic, on contractile fibre-cells; it induces in them more active tissue metamorphosis, and is therefore more useful, in diseases of organs largely supplied with these cells, as the abdominal viscera.

Faradism superior to galvanism in general electrization.

The faradic current is much superior to the galvanic in general electrization of the whole surface of the body, the peculiarly restorative and tonic effects of which, depend in part on the stimulus applied to the peripheral nerves, but in a greater degree to the infinite variety of muscular movements induced, by which more active oxidation of tissue is promoted and effete products removed.

Results affected by size and position of electrodes.

In operating with either the galvanic or faradic current, on any portion of the body, the result produced will be considerably affected by the size and position of the electrodes, the method of their applications employed, and the strength. The electrodes are made of metal, which is usually covered with moistened sponge, or one of them may be in the form of a metallic brush; this last is a very painful method of application, and is to be resorted to only in cases of excessive anæsthesia, or as part of the electric moxa, in severe and stubborn neuralgias.

The size and shape of the electrodes must depend on the position and nature of the parts to be operated on. Central galvanization, as a rule, requires large well-moistened electrodes; small finely-pointed ones are best adapted to local faradization of small muscles, and somewhat larger ones for larger muscles. It must be borne in mind, that the smaller the electrode, the more painful is its application, and that where difference in size exists, the current is more sensibly felt at the smaller one, and that electrodes moistened with salt water, conduct better than where plain water is used.

Methods of applying currents.

The methods of application are—

Stable, where both electrodes are kept in one fixed position.

Labile, where one or both electrodes are moved over the surface.

Voltaic alternatives, where the direction of the current is reversed during the sitting.

Voltaic interruptions, where the continuous current is broken by removing one of the electrodes, or by some form of current breaker.

Strength.

The strength of a current is said to be *uniform,* when no alteration is made in it during its application, *increasing* when it is gradually augmented.

For electrization of muscles, labile or stable, interrupted currents are to be preferred, as they produce muscular contractions and potent physical and mechanical effects.

For electrization of the head, spinal cord, sympathetic and nerve tracts and plexuses, stable continuous currents are indicated, which may be either uniform or increasing, as they produce the strongest electrotonic action. Electrization of muscles may be either direct or indirect, either applied over the body of the muscle to be excited, or through the nerve which supplies it; in the former case, the faradic current is to be used; in the latter, the galvanic.

The strength of the current employed is of the first importance. In all conditions of the central nervous system very mild currents should be used at first, which may be gradually increased if necessary; the same rule holds in applications to painful and irritable parts. Peripheral applications to muscles should have just sufficient strength to excite contractions. One rule should be borne in mind by the operator. It is always better to err on the side of mildness; the idea that the beneficial results will be in proportion to the strength, which the patient can be brought to endure, is wrong, and acting on it mischievous; experience proves that mild currents alone do good, and that much may be lost by painful applications.

Considerations in altering the strength of current.

The bodily condition and age of the patient must be considered in regulating the strength of the current, fat being a bad conductor, corpulent persons bear a stronger application than lean ones; and for the same reason perhaps, children can as a rule, tolerate peripheral currents of greater strength than thin elderly people. In the employment of either current, the aged must be treated with the greatest care and caution, as they are easily prostrated by a power which would barely affect the middle-aged.

Individuals who bear stimulants and tonics badly, are very easily affected by any form of electricity.

Length of applications.

The period during which the application should last at each sitting depends entirely on the nature of the disease and its locality. The operator must bear in mind, that during the time the current is flowing, important chemical and vital processes are being induced, and these may be carried too far. A patient may be overdosed with electricity as he may be with quinine, iron, wine, or any other restorative or tonic. As a general rule, ten minutes for the galvanic, and fifteen for the faradic current, are sufficient; but the discretion of the operator must be exercised in shortening or prolonging these periods. The galvanic current should be applied for a shorter time than the faradic, and central applications should rarely continue longer than half the period given to peripheral ones. The head, cervical spine, and sympathetic, require the shortest applications; the extremities the longest; the abdominal viscera, about the mean between the two. In faradizing a succession of muscles, one minute should be given to each.

Galvanic current to be applied for less time than the faradic.

Except in neuralgias no applications should be repeated oftener than once a day, and in many cases a longer period may elapse between them, without any detriment to the progress of the cure. Where the current can be employed daily, and the case is likely to be protracted, occasional breaks in the routine may be allowed; these may extend to a week at a time.

Frequency of applications.

As chronic diseases require chronic remedies, so must protracted diseases be attacked by protracted electrization, if no immediate benefit accrues. Cases in which diseases of long standing are cured by immediate treatment are too rare to be taken as a guide in prognosis. In many instances where electric treatment is indicated, some slight improvement usually appears after a few applications, if they are made with due knowledge of position, strength, and duration; but this has many exceptions, for it frequently occurs that no change is manifested for weeks, and then it suddenly occurs, and the cure becomes rapid and permanent.

Protracted electrization in chronic diseases.

When improvement may be expected.

Electrization should be avoided in active congestions and inflammations of organs, especially of the brain and spinal cord.

Direction of current and consequent effects.

With respect to the direction of the current and the position of the poles, the general principle to be observed is, that the descending current and positive pole are calming in their effects, while the ascending current and negative pole are irritating; on these grounds, we place the positive pole on the seat of tenderness in spinal irritation, and in neuralgias pass the descending current through the painful portion of the nerve; while in anæsthesias, motor-paralysis, and ataxies, we reverse the current. In all these cases we benefit, but the rule must be taken subject to the modifications which the operator's experience may bring to bear on it; for although founded on conclusions drawn from electro-physiological experiments, it is not always to be relied on, and in the present state of our knowledge it must be occasionally waived.

CHAPTER VI.

CENTRAL, LOCAL, AND GENERAL ELECTRIZATION.

Dr. Beard's method of central galvanization.

Before proceeding to describe the best means of applying the current to separate organs, a brief description of the method of central galvanization first employed by Dr. Beard may be found useful. By this procedure the whole central nervous systems — cerebro-spinal and sympathetic—are brought under the influence of the current.

The negative pole is placed on the epigastrium, the positive is applied over the head, around the sympathetic, and down the whole length of the spine. In applying the positive pole to the head, he gently passes it from one side of the forehead to the other, then places it for about a minute on the vertex; the current at first applied is very mild, gradually increased in strength until the patient has a metallic taste in the mouth, but sudden interruptions of current are avoided. On the neck, the pole is applied on each side, from the auriculo-maxillary fossa along the inner edge of the sterno-mastoid to the clavicle, for from three to five minutes, to affect the cervical sympathetics and pneumogastrics. On the spine, special attention is directed to the cilio-spinal centre below the sixth and seventh cervical vertebræ, as at no other external point in the body, can so many important nerves be influenced electrically; the entire length of the cord is treated by labile applications in both directions; the current applied here is from twenty to thirty cells, and the time occupied six minutes. The whole séance takes about fifteen minutes.

Galvanization of the brain.

Galvanization of the brain should be made with five cells, and increased to ten cells; the period should never exceed one minute. The electrodes should be broad, about an inch and a half in length by three-quarters of an inch in breadth; the negative pole should be nearest the neck, the positive nearest the forehead, when the current is meant to act upon the organ generally. To affect the base of the brain one electrode should be placed on each mastoid process; either hemisphere may be acted upon by placing one electrode above the supra-orbital foramen, and the other on the mastoid process of the same side. The brain can also be efficiently galvanized by placing one pole on the vertex and the other on the occiput.

Galvanization of the sympathetics.

The superior, middle, and inferior cervical sympathetic ganglia may be reached by the current in different ways, although, as already stated, from their anatomical relations other important nerves must be included in the circuit (for method of procedure, see pages 34 and 35). The strength of the current should not exceed fifteen cells, and the time not more than two minutes.

Galvanization of the cord.

In galvanization of the spinal cord the positive pole should be placed over the tender spot where the disease is supposed to be located, and the negative some distance below it. The whole column can be brought into the circuit by placing one pole at the occiput and the other at the coccyx, the strength employed may be from fifteen to thirty cells.

Benedikt makes the following divisions, which are usually accepted by electro-therapeutists :—

Spinal cord root current.—One pole on the spine, and the other drawn gently up and down by the sides of the vertebræ.

Spinal cord plexus current.—One pole on the spine, and the other on a plexus of nerves.

Spinal cord nerve current.—One pole on the spine, the other on the nerve.

Spinal cord muscle current.—One pole on the spine, and the other on a muscle.

Plexus nerve current.—One pole on a plexus of nerves, and the other on a nerve.

Nerve muscle current.—One pole on a nerve, and the other on a muscle.

Galvanization of the vaso-motor nerves.

The vaso-motor nerves of the upper extremity can be galvanized without acting at the same time on its sentient and motor nerves, by placing one pole at the junction of the second rib and second dorsal vertebra, and the other at the point of emergence of the seventh dorsal spinal root nerve.

Where it is not desired to act exclusively on the vaso-motor nerves of the upper extremity, one electrode may be placed at the point corresponding with the dorsal sympathetic, and the other in the axilla. If the patient places his hand on the opposite shoulder, the scapula will be drawn outwards and the dorsal point more easily acted on.

The vaso-motor nerves of the lower extremity can be reached by placing one electrode in the region of the inferior dorsal apophyses, and the other on the lumbar apophyses, where the sciatic nerve emerges from the pelvis.

None of these applications should exceed fifteen minutes, and the current should not be stronger than what is yielded by twenty-five or thirty cells.

The following are the best methods of applying a constant current to the nerves and organs specified :—

Galvanization of the pneumogastric.

The pneumogastric nerve.—By placing one pole at the angle of the lower jaw, and the other at the junction of the sternum with the inner edge of the sterno-mastoid muscle; strength, ten to fifteen cells; time, two minutes.

Galvanization of the nerves of special senses.

The olfactory nerve.—The negative pole on the Schneiderian membrane, and the other on the cheek of the same side; strength, five cells; time, from three to five minutes.

The optic nerve.—The positive pole on the closed eye, the negative on the palm of the hand for three minutes; then reverse the poles, and apply for three minutes longer; strength, fifteen cells.

The auditory nerve.—Press the positive pole a little way into the external meatus, previously filled with warm water, and place the negative in the auriculo-maxillary fossa of the opposite side or at the nape of the neck; time, two minutes; strength, ten cells.

The gustatory and glosso-pharyngeal nerves.—Place one pole on each side of the lower jaw, directly beneath the sublingual glands; time, five minutes; strength, fifteen cells.

Galvanization of important nerves and plexuses.

The following are the points where the principal nerves, plexuses, and branches can be best excited electrically (taken from Beard and Rockwell's treatise, and verified by me on healthy living subjects).

Facial nerve, at the opening of the external auditory canal.

Accessory, at its exit from the sterno-mastoid muscle.

Phrenic, between the anterior border of the scalenus anticus, and the outer border of the sterno-mastoid, close to the omo-hyoid. Excitation of this nerve causes strong movements of the chest.

Brachial plexus, in the supra-clavicular space, posterior to the outer border of the sterno-mastoid. Excitation of this plexus produces tingling and numbness down the arm to the fingers, and with a stronger current flexion of the fore-arm and fingers.

Musculo-cutaneous nerve, between the biceps and coraco-brachialis.

Median nerve, in the lower third of the arm at the point where it crosses the brachial artery. Excitation of this nerve causes pronation of the hand and closure of the fingers.

Ulnar nerve, at the groove between the olecranon and internal condyle. Excitation produces contraction of the flexor carpi ulnaris, flexor digitorum profundus, adductor pollicis lumbricalis, and interossei of the little finger.

Radial nerve, in the lower third of the arm, at the point of emergence from beneath the triceps. Excitation produces extension of the first phalanges of the fingers, extension of the hand and thumb, and supination of the fore-arm, contractions of the extensor carpi radialis and ulnaris, extensor digitorum communis, extensor minimi digiti, extensor indicis, extensor pollicis longus and brevis, adductor pollicis.

Ischiatic nerve, in the thigh, posterior to the head of the femur. Excitation causes tingling below the knee.

Crural nerve, just after its exit beneath Poupart's ligament, exterior to the crural artery.

Obturator nerve, on the horizontal branch of the pubic bone. Excitation causes abduction of the thigh.

Popliteal nerve, in the outer part of the popliteal space. Excitation causes vigorous contractions of the muscles that move the foot upward and outward.

Peroneal nerve, on posterior border of the capitulum fibular. Excitation induces contractions in the tibialis anticus, peronei muscles, extensor digitorum communis longus, and extensor digitorum communis brevis.

Tibial nerve, on the middle and outer part of the knee. Excitation induces contractions in the muscles of the posterior part of the leg.

Very many muscles have no accessible motor points, and must be acted upon intra-muscularly, and practically this is the course pursued in the majority of cases.

Galvanization of pharynx, &c. &c.

The pharynx and œsophagus can be easily reached by placing one pole on the organ internally, and the other at the nape of the neck.

The larynx can be placed under the influence of the current by placing one pole in the form of a wire brush to the skin in front of the larynx, and the other well moistened on the nape of the neck.

Galvanization of the liver, &c. &c.

The abdominal viscera.—The stomach, liver, spleen, kidneys, and intestines may be directly acted on by placing one large sponge electrode over the organ to be operated on, and the other on the opposite point of the back, so that the current may pass directly through.

The anus and rectum.—One olive-shaped metallic pole in the rectum, previously cleared out by enemata, and the other externally on either side of the anus.

The bladder and urethra.—For the former, one pole is placed in the bladder, in which the urine has been allowed to accumulate, and the other on the symphysis pubis or the perineum; for the latter, one pole is placed internally on the portion to be acted on, the other externally, as for the bladder.

Uterus.—One pole may be placed at the os, the other in the bladder; or one on the pubis, and the other in the lumbar region.

Male genitals.—These are best operated on when placed in a vessel of tepid water attached to one of the poles, while the moistened sponge of the other pole is placed transversely on the two last dorsal vertebræ.

General Electrization.—The whole surface of the body can be effectually brought under the influence of the current by the patient standing on a copper plate connected with one of the poles; while the other, in the form of a broad, flat, sponge-covered plate, with an insulated handle, is drawn gently over the whole surface of the body for ten minutes.

CHAPTER VII.

ELECTRO-DIAGNOSIS.

Electro-diagnosis.

ALL parts of the human body are in some degree sensitive to electric action, and this natural condition is affected by disease. Organs or tissues which become abnormally sensitive from disease feel severely the effect of the current. On the other hand, those which become indurated, or in an anæsthetic state, are much less easily affected than in health.

In nervous dyspepsia.

In nervous dyspepsia the current will usually produce considerable discomfort if applied over the spleen and epigastrium, or through the solar plexus. A sensation of sinking and faintness usually accompanies the passage of a continuous current from the seventh cervical vertebra to the epigastrium. A congested liver may be detected by the unusual pain and discomfort a galvanic current passed through, will produce, while a seriously diseased one will make no response whatever, or only in a very slight degree.

In hepatic disease.

In neuroses.

As might be expected, electricity as a means of diagnosis is more applicable in diseases of nervous centres and tissues than of any other class. The brain is easily affected in health,

The brain.

and the sensitiveness may be greatly increased or diminished by disease. The spinal cord in health is but little affected, while in disease it manifests a degree of sensibility which can be detected in no other manner. The sympathetic is abnormally sensitive in most forms of brain disease, in locomotor ataxy and muscular atrophy.

Cord.

Sympathetic.

Degrees of electro-muscular contractility.

Increase of electro-muscular contractility may be observed in diseases of the brain, attended with irritative lesion; in most spasmodic and hysterical affections, and in locomotor ataxy.

Diminution of electro-muscular contractility occurs in hemiplegia from cerebral hæmorrhage, in severe diseases of the spinal cord, especially the antero-lateral columns, in lead palsy, in rheumatic and hysterical paralysis, in muscular atrophy, and in paralysis from injury to the trunk of a nerve.

Detection of feigned diseases.

Feigned diseases, if they assume the form or are intended to represent nervous lesions, can be readily detected by the current; for no power of volition can resist the action of a powerful current on the muscles of a healthy limb, or the pain of the faradic current applied to a sensitive skin through the medium of the wire brush.

Galvanic probe and indicator.

Metallic bodies, such as bullets, embedded in wounds, can be detected by a delicate galvanic current. The presence of the metal is indicated by the movements of a needle, or the stroke of a bell, when the circuit is closed by contact with it.

The electro-magnet has been suggested as a means of extracting metallic bodies from the eye, urethra, auditory canal, &c., but there is no record as yet of results.

Electricity a test in doubtful cases of death.

In cases of doubt as to whether an individual is really dead or only in a trance, electricity, especially the faradic current, furnishes the simplest and most reliable test; this subject has been fully investigated by Dr. Crimotel,* of Paris, and Professor Rosenthal,† of Vienna, with corresponding results.

Electro-muscular contractility exists not only during health, but also during disease; thus it is found in apoplexy, lethargy, syncope, profound drunkenness, all kinds of asphyxia and poisonings, so long as life is extant; it is not lost at the moment of death, but gradually diminishes and is entirely gone in all instances after three hours. When faradic contractility is gone, we may pronounce with certainty that life has gone also.

Duration of faradic excitability after death.

Post-mortem faradic excitability disappears more rapidly after chronic than acute diseases, and remains longer in well nourished than in wasted bodies; in newly-born infants it may continue from fifteen minutes to an hour after the heart has ceased to beat; in cholera, typhus, phthisis, &c., it rarely lasts beyond thirty minutes after death. It must be noted that in certain forms of paralysis faradic contractility may be lost, but this does not extend to all the muscles of the body; in muscular atrophy, with or without fatty degeneration, the diaphragm will respond to faradism of the phrenic nerve.

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* "De l'Épreuve galvanique, ou Bioscopie électrique." Paris 1866.

† "Medicinische Jahrbücher," iv. Heft, 1872.

CHAPTER VIII.

ELECTROLYSIS AND THE GALVANIC CAUTERY, &c.

THE negative and positive poles of a galvanic battery, when placed in solutions of various substances, have the effect of resolving them into their original elements, and this power is so universal that very few compounds in a liquid or semi-liquid state can withstand it. On solids the effect is not so marked, because it is necessary for decomposition, that the minute particles of which a substance is composed, should have power of motion sufficient to enable them to obey those laws of attraction and repulsion, on which the special electrolytic effect depends.

At both poles of the battery decomposition is taking place, but the appearances at each are different, as also are the products: for example, in blood and ordinary animal tissues, acids, albumen, fibrine, &c., appear at the positive; alkalies, watery extracts, soda, potassa, &c., at the negative pole. This special action of the electric current is termed electrolysis, a name given to it by Professor Faraday to distinguish it from ordinary chemical decomposition. As most morbid growths, though in many instances firm and solid in external appearance, are composed of blood-vessels and cells, the latter generally containing either serum or lymph, or some peculiar fluid or juice, they are fully under the control of the electrolytic action, which is as quick and certain upon them as upon any chemical solution out of the body. The decomposition so produced entirely destroys the character of the diseased structure, and resolving it into its elements, allows the absorbent vessels of the parts to take it up, while the effect produced upon the nutrition of the secreting tissues is so profound, that all chance of a return of the disease is obviated.

The electrolytic action is attended by very little discomfort, as the current is scarcely perceptible; the most pain felt is in the passing of the needles into the structure to be operated on, and if this be done carefully and rapidly, and the part of the needle which remains in the integument be insulated, the annoyance is hardly noticeable. The employment of needles with cutting edges is, I find, a great improvement upon the ordinary round needle with a sharp point only, as the resistance of the integuments is at once overcome, and with considerable saving of pain to the patient.

The batteries best adapted to the purposes of electrolyzation are Daniell's, Foveaux's, Stöhrer's, and Mayer and Meltzer's. Daniell's, from its size, can only be used in the consulting or operating room, while the others, being compact and portable, may be easily employed at the patient's home. Platinum wire is the best material for needles, but gold or steel gilt answers all practical purposes, and the latter has the advantage of furnishing the most perfect cutting edge.

A fair idea of what takes place in a serous cyst, or in the body of a tumour during electrolyzation, may be acquired by studying the phenomena presented by the action of the current on dead animal tissue, such as lean meat, &c. At the negative needle a hissing sound may be heard, as the bubbles of hydrogen perceptible to the eye are rapidly given off, and chemical examination shows that alkalies and colouring matter are also attracted to this pole, while acids, albumen, and oxygen go to the positive. After the electrolytic action is arrested, the process of disintegration, discoloration, and drying continues for some hours, until the portion operated on shrivels, contracts, and crumbles away. In the living tissue the influence of the current is even more marked, as animal heat materially assists in the conduction of electricity, and renders the process of absorption easier and more rapid.

To sum up, the influence of electrolysis on morbid (as on healthy) structures in the human body consists of three distinct actions:—

Decomposition.—As the body is mainly composed of water holding various substances more or less in solution, and liable to early and rapid decomposition, the electrolytic action of both poles sets all these elements free, as it would in an ordinary chemical solution, and some of these undergo a secondary change, not only still further removed from the original combination, but themselves (as soda and potassa) acting as powerful chemical solvents.

Disintegration.—Althaus has shown by his experiments that "the evolution of hydrogen forces itself between the structural elements of the tissues, driving their fibres mechanically asunder," and thus exposing them more fully to the decomposing and absorbing actions.

Absorption.—This takes place during the operation, and continues for some time afterwards; it may be hastened perhaps by the chemical changes alluded to, but as far as at present known, is mostly dependent on the direct stimulus given to the vaso-motor nerves by the electric current.

Tumours, as a rule, increase in size for a short time after the application of electrolysis. This, as may be understood from the foregoing, is caused by the evolution of the hydrogen gas, but that soon becomes absorbed, and after a short time the unhealthy mass begins to decrease in size, and if sufficiently fluid in its construction, to entirely disappear. Should it be dense in structure, it is generally necessary to repeat the operation a number of times before complete obliteration takes place. It is rarely necessary to introduce the positive pole into the substance of a tumour, the negative being quite sufficient—

indeed, the introduction of the positive pole is rather to be avoided, as its application is sometimes followed by suppuration, a result I have never seen take place after the use of the negative only.

A few needles—the number depending on the extent of the mass to be removed—being introduced into the substance of a tumour, are attached by a conductor to the negative pole of a battery such as already mentioned, and the circuit completed by placing an electrode attached to the positive pole on some part of the body near the seat of the disease. The current, its power proportioned to the density of the diseased structure, is then allowed to pass through for from five to twenty minutes, according to circumstances; during this time the phenomena already described are steadily going on, and not only the vitality, but the very nature of the morbid growth is destroyed. No bleeding, inflammation, or other unpleasant symptom follows, and the patient can at once pursue his or her usual avocations without any precaution whatever.

The subject of electrolysis is too extensive to be fully treated here; but enough has been shown to demonstrate what a very important branch of practical surgery it must become, and how worthy it is to receive the systematic attention of the profession. It is, to use the words of the latest inquirers into its phenomena, "in its scientific and practical relations, as illustrated by experiments, and in its application to disease, one of the most fascinating studies to which the human mind can be brought;"[*] and its electro-surgical influence may be expressed in the words of another scientific inquirer: "No animal tissue whatever can withstand the disintegrating effect of the negative pole; and the force and rapidity with which this disintegration is brought about are directly proportional to the electro-motive force employed, and to the softness and vascularity of the structures acted upon."[†]

Galvano-cautery.

Galvano-cautery.—When an electric current is forced through a resisting medium the temperature of that medium is raised in proportion to the quantity of the fluid forced upon it and its power of resisting it. Such a condition generates heat in the medium, the intensity of which is entirely under the control of the operator, who can apply it to a cancer, tumour, or any diseased mass in such a manner as to cause its complete destruction or removal in a very short space of time. No bleeding accompanies or follows its use, nor any constitutional disturbance, and it can be applied with the greatest certainty and safety to various parts not readily accessible to the surgeon's knife, while it is so reliable in its action and so fully under control, that it can be localized in the most delicate structure, and in the neighbourhood of the most important parts and organs, with more certainty and safety than any other surgical or therapeutical agent.

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[*] Beard and Rockwell, "Experiments in Electrolysis." New York. 1871.

[†] *Vide* Althaus, *op. cit.*

Diseased structures removed by the electric écraseur.

The process by which these effects are produced, may be named *electric excision*, and the instrument the *electric écraseur*. In this country it has been applied successfully in the removal of cancers in the breast, lip, tongue, uterus, penis, and almost every other part of the external surface of the human body where malignant growths are found. It is too early yet in its history to say with certainty that electric excision precludes all possibility of a return of the disease; but the profound alteration produced in the parts operated on gives us reasonable hope of a non-recurrence of the malady.

The batteries used in these operations differ materially from the ordinary galvanic batteries; the object being to utilize the calorific effects, a few cells with a large surface are employed. The principal batteries of this class are Middeldorpf's, Grenet's, Von Brun's, Stöhrer's, Mayer and Meltzer's, and Kidder's; of these Mayer and Meltzer's is the best for general purposes, it combines lightness and portability with power, and the degree of heat employed is entirely under the control of the operator, a matter of great importance.

Description of electric écraseur.

The electric écraseur merits a few words of description, however. It consists of a moveable platinum wire attached to an ivory or ebonite handle, in the form of a loop. This handle is divided into halves, through each of which runs a gilded copper wire, one connecting with the positive, the other with the negative pole. One of the wires is divided so that it can be united by turning a screw when it is desired to complete the circuit. At the upper end of the handle the platinum wire is attached to both wires, so that merely turning the screw throws it into electric action; at the lower end a wheel is attached, by turning which the loop may be gradually contracted, so as to firmly embrace the base of the diseased structure, while in the act of removing it.

CHAPTER IX.

TERMS EMPLOYED IN ELECTRO-PHYSICS, ELECTRO-PHYSIOLOGY, AND ELECTRO-THERAPEUTICS.

Anelectrotonus.—The state of diminished irritability which appears at the positive pole when a nerve is in the electrotonic condition (p. 31).

Anions. — The electro-positive substances which, during the electrolytic process, go to the negative pole.

Anode.—The positive pole (where the current enters).

Armatures.—Bars or keepers which, when placed in contact with the pole of a magnet, preserve its magnetism.

Ascending.—When the current passes from the periphery of a nerve or nerves to the nervous centres.

Catalysis.—The condition of extreme polarization in a nerve (see Polarity).

Catelectrotonus.—The state of increased irritability which appears in a nerve at the negative pole, when it is in the electrotonic condition (p. 31).

Cathode.—The negative pole, where the current passes out.

Cations. — The electro-negative substances, which in the electrolytic process go to the positive pole.

Commutator.—The instrument by which the current is reversed.

Coil.—See Induction.

Condenser.—An apparatus for condensing a large quantity of electricity on a small surface.

Constant current.—The galvanic current.

Continuous current.—The galvanic current, when constantly flowing in one direction.

Contractility, electro-muscular.—That property in a muscle which causes it to contract when acted upon by an electric current.

Copper pole.—Positive pole.

Derived current.—See page 14.

Descending current.—From the centre to the periphery.

Diamagnetism.—That property in a body by which it is enabled to manifest the same magnetic phenomena as iron.

Dielectric.—Any medium through which induction is propagated.

Diplegic contractions.—See page 35.

Dynamical electricity.—Electricity generated by chemical action in motion. The voltaic, or galvanic, or faradic currents.

Electrode.—The way by which positive and negative electricities emerge. The positive pole is connected with the negative element, and the negative pole with the positive element.

Electrolysis.—The process by which any compound substance can be decomposed by electricity.

Electrolite.—Any substance which can be electrolyzed.

Electrometer.—An instrument for measuring the charge of a battery.

Electro-motive force.—The power by which electricity is set in motion in a galvanic circuit.

Electrophorus.—A contrivance for collecting electricity by induction.

Electroscope.—An instrument for detecting the presence and character of electricity in a body.

Electro-Surgery.—See page 65.

Electro-therapeutics.—The art of applying in a scientific manner all varieties of electricity in the treatment of diseases.

Electrotonus.—The condition induced in a natural nerve current by the action of the galvanic current upon it.—See. page 30.

Elements, galvanic or voltaic.—Two heterogeneous metals immersed in an acid solution; called also couple, pair, or cells. Two or more of these form a battery, as Daniell's, &c. &c.

Faradic current.—The electro-magnetic and magneto-electric currents, discovered by Faraday; called also the induced or interrupted current.

Frictional electricity. — Electricity generated by friction, as in the original electric machine; called also static.

Galvanic circle.—The galvanic element, pair or cells, or any number of them, in action.

Galvanic current.—The stream of electricity generated by the elements or cells in action, and flowing directly from them; called also the continuous and constant.

Galvano-cautery.—See page 70.

Galvanometer.—An instrument to determine the presence and direction, and as nearly as possible the quantity and intensity, of a current; called also a multiplier.

Helix.—The coil of wires required in an electro-magnetic apparatus.

Heteronymous poles.—Poles turned in the same direction.

Induced current.—The current induced in a coil of wires, from another coil through which the current actually passes.

Induction.—The action which electrified bodies exert on bodies in a natural state.

Intensity.—The quantity of electricity which in any unit of time flows through a section of the circuit. The property of electricity which overcomes resistance; called also tension.

Insulated.—Placed on non-conducting supports.

Interrupted current.—Applied usually to the faradic current; but the galvanic current, although in itself continuous, is sometimes interrupted by breaking, or opening and closing the circuit in regular succession.

Ions.—The constituents into which an electrolyte can be decomposed.

Irritability, electro-muscular.—That property of muscular fibre by which it is excited to movement by the electric current, distinct from electro-muscular contractility, which may be wanting.

Labile current.—One or both of the electrodes are moved over the surface of that portion of the body to be acted on.

Leyden jar.—See page 8.

Magneto-electricity.—The variety of faradism in which the current is induced by a magnet (see page 22).

Motor points.—Points on various parts of the body where nerves and muscles respond most readily to electrization.

Multiplier.—See Galvanometer.

Negative.—Where the current passes out: the cathode. The current is felt stronger at this pole than at the positive.

Polarity.—That property in bodies in which peculiar phenomena of the positive and negative poles are exhibited at certain points. The polarity of a nerve, is that condition in which it manifests at one part, a positively and at another a negatively electric state.

Polarizing current.—The current which produces in a nerve the electrotonic state.

Poles.—In magnetism, the points where the magnetic fluid is concentrated; in electricity, the points where the electricity passes in or out.

Primary current.—The current which passes through the inner coil of wire in a helix, and induces a current on the coil which surrounds it, and which is called the secondary current.

Primitive current.—See page 14.

Quantity.—The amount of electricity generated—always in proportion to the amount of chemical action present.

Resistance.—That property in a body which enables it to resist the passage of a current.

Rheocord.—An instrument for controlling the fluctuations of the current.

Rheophores.—The wires which conduct the current from the battery to the patient.

Rheotome.—The current breaker.

Secondary current.—See Primary current.

Shock.—The sudden discharge of electricity given by a Leyden jar (see page 10).

Stable current.—When the electrodes are fixed during the application.

Statical electricity.—Electricity generated by friction, cleavage, or pressure.

Tension.—See Intensity.

Voltaic alternatives.—Produced by changing the direction of the current during its application.

Voltaic interruptions.—See page 49.

Voltaic pile or battery.—One of the earliest arrangements for producing the galvanic current.

Zinc pole.—Negative pole.

PART II.

Diseases in which Electrical Treatment may be employed with advantage, either alone, or as an adjunct to other remedies.

Amaurosis.—Complete and partial loss of sight from this cause have been treated by all forms of electricity, with varying results. De Saussure cured a case by shocks of static electricity through the eyeball to the neck; Magendie, Person, and Dunn, by magneto-electricity; Lesueur, by electro-magnetism. The continuous current has been applied in various instances, but with less satisfactory results, although from its physiological action on the faulty nerve, much might be expected.

Amenorrhœa.—Out of twenty-four cases Dr. Golding Bird cured twenty, by shocks from a small Leyden jar—one conductor on the lumbo-sacral region, the other close to, but above the pubis. The intra-uterine galvanic pessaries have been used with advantage by Sir J. Simpson. Faradism of the womb has been successful in many hands. The most reliable form of electrization, and the least objectionable in its mode of application, I find to be the galvanic current, which I usually apply for twenty minutes daily, from the symphysis pubis to the lumbar spine. Strength of current, about thirty cells; number of applications, from ten to thirty.

ANEURISM.—Ciniselli cured an aneurism of the descending aorta by galvanic puncture; McCall Anderson, one of the thoracic aorta; Brandis, a large femoral aneurism; Duncan, a cirsoid aneurism on the left side of the head; Meyer, an aneurisma racemosa of the left knee.

APHONIA, complete or partial, has been frequently cured by faradism of the larynx and tongue.

ASPHYXIA.—Ziemssen has restored five cases due to charcoal fumes, carburetted hydrogen, and freezing during intense intoxication, by faradism of the diaphragm through the phrenic nerves. Pernice restored two out of five stillborn children in the same manner.

ASTHMA.—Althaus recommends anelectrotonus of the pneumogastric with faradism of the phrenic. I have seen much relief produced by this combined treatment.

BASEDOW'S DISEASE, occurring mostly in females between twenty and thirty years of age, and attended by palpitation of the heart, enlargement of the thyroid body, and exophthalmic goitre, has been successfully treated by Dr. Wietfield and Moritz Meyer by galvanism of the cervical sympathetic, &c.

BLADDER, ATONY OF, from overdistension, usually yields to faradism.

Bladder, paralysis of, from central nervous disease.—As of the pedunculus cerebri or lumbar portion of the cord; unless actual destruction of nervous matter has taken place, the constant current may be applied with almost complete certainty of success. Where the pedunculus cerebri is judged to be at fault, the negative pole is placed at the back of the head, the positive above the symphysis pubis. Where the seat of mischief is in the cord, the negative pole is placed on the lumbar spine, the positive as in the foregoing case. Voltaic interruptions are preferable to the stable current; the time occupied should be twenty minutes, and the number of cells used, about thirty for the cerebral and fifty for the spinal.

Bladder, hysterical paralysis of.—This not unusual ailment in delicate hysterical women, generally yields to galvanization of the cervical sympathetic and cord, followed by faradization of the organ itself.

BRONCHOCELE.—The cystic variety yields quickly to electrolysis. Cases have been successfully treated in this manner by Althaus, Mackenzie, myself, and others. The solid varieties are more stubborn, but usually yield, if the applications are sufficiently prolonged. Beard and Rockwell cured one case with twenty applications; Dr. Wahltuch, of Manchester, another with sixteen applications; in the latter instance, subcutaneous injections of iodine were combined with the electrolytic treatment.

CANCER, EPITHELIAL.—M. Zielewicz has collected forty-eight cases of amputation of the penis, by the galvanic wire, for this disease, in forty of which the operation was successful. No hæmorrhage followed, nor sympathetic fever, and contraction of the urethra occurred only in one case, but it was speedily cured by the bougie.* Erichsen and Bryant have used the galvanic écraseur successfully in a considerable number of cases of cancer of the tongue, and the latter also in epithelial cancer of the perineum. Professor Groth has treated eighteen cases of epithelioma by electrolysis, in which thirteen were completely cured. Beard and Rockwell and I have also been successful in the electrolytic treatment of this disease. In *scirrhus* I have amputated four breasts by the galvanic wire and knife, without hæmorrhage or subsequent fever, but in each case, although a good recovery was made at the time, the disease returned after some months. Neftel, of New York, has been more successful in primary and secondary cancer by electrolytic treatment, as also has Professor Mussey, of Philadelphia, in secondary cancer.† Dr. Neftel agrees with Virchow that malignant tumours may at first be quite local, that they are not inherited, only the predisposition to them; the principal thing then to secure success is to commence the treatment in the early stages. Kühne, Goluben, Engelman, and others have shown that electricity has a powerful effect on protoplasma, the vital properties of which may be modified or destroyed by it. This molecular and general effect is, according to Neftel, the most important influence of electrolysis. The hydrogen given off during electrolysis is a powerful destroyer of the protoplasma of the cancerous cells, and they thus lose their vital properties. Cancerous cells, it is proved under the microscope, are more easily destroyed by the galvanic current than healthy cells; so that if a feeble current be applied, the cancerous elements may in this manner be eliminated without injury to the healthy parts. Dr. Neftel does not believe that electrolysis by means of needles, alone is sufficient to cure cancer, but that persistent external applications of the galvanic current are required to supplement it. He recommends the same treatment in incurable cases as a palliative remedy, because it relieves pain and improves the general condition of the patient; this latter occurs in a remarkable manner, even in very bad cases—the lancinating pains disappear; appetite, digestion, and sleep return. I have electrolyzed a number of cancerous breasts, but my cases have been too far advanced to meet the requirements of complete cure laid down by Dr. Neftel. The severe pain has in all instances been relieved, and the rapid development of the disease in the greater number of instances arrested; so that I may say the fatal termination has in these instances been indefinitely postponed; the general health has been improved, and, with better sleep and increased appetite, hope has returned to the patient, and life made more desirable.*

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* Langenbeck's "Archiv," 1871, p. 587.

† See further on this subject, Althaus' "Medical Electricity." London: 1873.

CHLOROFORM SYNCOPE.—Friedberg† restored a boy, aged four years, by faradization of the diaphragm;

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* See Dr. Neftel's paper in Virchow's "Archiv," vol. lvii. 1873.
† Virchow's "Archiv," vol. xvi. p. 527. 1859.

one electrode on the phrenic in the neck, the other in the seventh intercostal space, for one second at a time. The first inspiration took place after ten such applications. Dr. Hardie, of Manchester, has restored life in two similar cases. Mr. Green, of Bristol, records seven cases treated by magnetic electricity, five of which recovered; of the two fatal cases, one had fatty heart, and in the other much time had been wasted in the employment of other means before electricity was resorted to. In all the cases the applications were made to the neck and the lower ribs on the left side. Mr. Prichard, of Bristol, restored two patients to life by faradization: both were aged. One electrode was placed at the nape of the neck, the other on the epigastrium.

CHOREA.—Golding Bird reports thirty-seven cases treated by static electricity, thirty of whom were cured. He found the rapidity of cure was nearly in proportion to the facility with which the papular eruption on the skin, peculiar to the application of this form of electricity, was produced. Addison, Sir Wm. Gull, and others have also employed static electricity with good results. Althaus has been successful with galvanization and faradization of the limbs alternately, combined with gymnastic movements. Benedikt has cured twenty cases by galvanization of the spine. Beard and Rockwell have cured eight out of thirteen cases by general faradization. I have been successful in five out of eight cases by the same treatment, and in the remaining three by the same treatment combined with the internal employment of arsenic.

CHLOROSIS.—The theory of the origin of this disease, which receives the most favour from the profession, is, "that the process of development, which we term puberty, is under the control of the ganglionic system, which at that time must necessarily be in a condition of excessive susceptibility, and in the female this state of nervous exaltation often produces functional derangements, which create a collection of symptoms, to which the name chlorosis is given."* If this be correct, we would look for good results from galvanization of the sympathetic system, and the experience of the few cases, which I have had an opportunity of treating in this manner, warrants me in recommending it to the profession, as an important adjunct to the usual treatment.

CONSTIPATION.—Habitual, from deficient power in the abdominal muscles, and impaired peristaltic action in the contractile fibre-cells of the intestines, can be overcome by direct faradization of the rectum, or by labile applications of the same current over the whole of the abdominal parietes. Dr. Macario, of Genoa, reports a case of obstinate constipation, ending in stercoraceous vomiting, in which the patient, aged seventy-one, was permanently cured by him. He introduced a metallic electrode attached to a faradic apparatus into the rectum; the other electrode, covered with a moistened sponge, was placed over the transverse colon; the current was allowed to pass for ten minutes; during its action the muscles of the abdominal parietes contracted violently, and four hours after the current was withdrawn copious evacuations commenced, and continued until the canal was thoroughly cleared.

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* "Diseases of Women." By Professor T. G. Thomas. Second Edition. P. 626.

DEAFNESS, MUCOUS.—Accumulations of mucus in the middle ear, with or without thickening and adhesions, which will not yield to the ordinary remedies of the aurist, may be removed by electrolysis. The cavity is first injected with warm water, or a weak tepid solution of soda or potass; a delicate copper wire attached to the negative pole, and insulated, except at the extremities, is then carried through a catheter to the throat opening of the Eustachian tube, and passed along its course into the liquid; the other pole, covered with moistened sponge, is placed in the outer meatus. The current employed should be very mild, five cells usually being sufficient. The patient is cognizant of the electrolytic action by hearing the crackling produced by the ebullition of the hydrogen. In strictured Eustachian tube the negative pole, guarded as in the previous case, is pressed down to the stricture, and allowed to rest upon it until it is destroyed, which usually occurs in about three minutes; no unpleasant effects follow. When there is anchylosis, partial or complete, malposition of the membrana tympani, or paralysis of the tensor muscle, the faradic current will be found useful.*

DEAFNESS, NERVOUS.—Dr. Moos, of Heidelberg, an accomplished and experienced aurist, has published a case of recovery from nervous deafness of a very remarkable and encouraging character. The patient, a lady aged nineteen years, was attacked on the 9th of February, 1869, after acute articular rheumatism, with symptoms of acute intercranial disease of an hysterical character. She became deaf to noises, and for several weeks it became necessary to communicate with her by writing. She was examined by Dr. Moos on the 29th of April, and he came to the conclusion that there was perfect paralysis of both auditory nerves. On the 10th of May she was first treated by the galvanic current, which was applied daily from that time till the 12th of July. On the eleventh day of treatment she heard her own voice in the left ear, immediately after the galvanic application. On the 18th and 24th of June conductibility of tones was noticed for the first time; on the 12th of July, two months after commencement of treatment, she could hear the watch on the right side 10 feet, on the left 9 feet. The treatment now caused giddiness, and it was gradually abandoned; six weeks later her hearing was fully restored.

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* See further on this subject the author's work, "Deafness treated by Electrolysis." Longmans and Co. London.

Dr. Moos also relates another case of complete deafness after cerebro-spinal meningitis, complicated with tinnitus aurium, vertigo and headache; after twenty-two applications the hearing power was raised to eighteen paces, and the noises and giddiness much diminished.* Brenner cured a case of deafness complicated with facial paralysis by the galvanic current. Duchenne reports cases of nervous deafness cured by faradism.* In a case of nearly complete deafness following secondary syphilis, in which I believed the loss of hearing to depend on the pressure of gummata in the sheath of the auditory nerve on each side, the hearing was restored after a three months' course of galvanization; the current employed never exceeded ten cells of Daniell's battery; the applications were daily for one month, when considerable improvement manifested itself; then on alternate days for the following six weeks, by which time the full measure of hearing was attained, and then twice a week for the next fortnight.

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* "Archives Ophthalmology and Otology." Vol. ii. No. 1, p. 332.

DEGLUTITION, DIFFICULT, from spasm or paralysis of the pharynx or œsophagus. Althaus cured a case by the combined action of galvanism and faradism; Hiffelsheim by galvanism of the pneumogastric; in one very distressing case under my care the patient was completely cured by galvanism. One pole protected by moistened sponge (positive) was placed on the pharynx, the other on the epigastrium. The applications could not be prolonged beyond thirty seconds in consequence of the retching induced, but they were repeated twenty times during each séance. The number of séances did not exceed ten.

DIABETES.—Where the disease has not progressed as far as degeneration of nerve tissue at the roots of the pneumogastric nerves in the floor of the fourth ventricle, we may reasonably hope to alleviate if not cure this distressing disease by the continuous current. Mariano Semmola, in the "Comptes Rendus," 1861, vol. liii., states that electrization of the pneumogastric by either current, reduces the amount of sugar in diabetic urine, and sometimes the quantity of the fluid, and the result of the treatment, from his experience, is permanent or temporary according to the structural condition of the nervous centres implicated.

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* "De l'Electrisation Localisée," &c. Paris: 1861.

DIPSOMANIA.—Althaus states that he has seen several instances, where the morbid desire for alcohol was rapidly checked, when the cerebrum, spine, and cervical sympathetic were brought fully under the influence of catelectrotonus. In my work on nervous exhaustion—article Dipsomania—I record two obstinate cases successfully treated by me by galvanization of the spinal and sympathetic nerves.

DYSPEPSIA, NERVOUS.—Where dyspepsia exists without any structural lesion, galvanization of the spinal cord and pneumogastric, with occasional applications to the epigastrium, will be found of great benefit. Many cases in my own practice and that of others might be cited as evidences of this.

EPILEPSY.—Intractable cases which resist all other treatment are occasionally benefited by galvanism, especially where an aura exists, but the results on the whole are not so satisfactory as to warrant its application unless where all other means have failed.

FACIAL SPASM (histrionic spasm, tic convulsif), arising from irritation of some branches of the fifth pair of cerebral nerves, has been cured by Remak and Benedikt by the continuous current; in this country, unless in very recent cases, the result has not been satisfactory.

GASTRODYNIA.—Severe cases of this disease, which have resisted the usual remedies, can generally be cured by mild galvanic applications, as it arises from functional derangement of the solar plexus. The positive pole should be placed on the epigastrium as nearly as possible on a level with the central ganglion, the negative on the corresponding portion of the spine; the strength of the current should not exceed twenty cells, nor the time fifteen minutes. If after a few applications a marked improvement is not made, the direction of the current should be reversed.

GOITRE.—See Bronchocele.

HÆMORRHAGE, POST-PARTUM.—No remedy is at all comparable to faradism in profuse floodings after labour. Where pressure, ice, ergot, introductions of the hand, plugging, &c., have failed, the interrupted current has rapidly succeeded in inducing uterine contractions and arresting the discharge of blood. Mr. Parsons, of Liverpool, employed it after the usual means had been unsuccessful in a case of twins, where the patient with a large and flabby uterus was sinking from loss; one electrode was placed on the cervix, the other on the abdominal parietes; in half an hour the womb had fully contracted, and the hæmorrhage arrested. Dr. Mackintosh, of Doncaster, was equally successful. In his case, forceps delivery had been necessary;

the uterus was flabby, and would not contract after removal of the placenta; grasping the organ externally, cold affusions, injections of cold water and perchloride of iron failed to arrest the hæmorrhage, which could only be controlled by keeping the hand in the organ. Under these circumstances, faradization was resorted to; immediately firm contraction took place, and the hæmorrhage ceased. Both women made good recoveries.

HEADACHE, not depending on stomach derangement, yields readily to mild faradism or galvanism. Sick headache (hemicrania) is invariably overcome by the latter current through the mastoid processes and temples. Did space permit, many cases might be cited in proof of this.

HÆMORRHOIDS may be safely and quickly removed by electrolysis.

HERNIA, INCARCERATED.—Faradization has been successfully employed in one case of femoral hernia, by M. Delaux, of Toulouse. The patient refused to be operated on; when the bowel had been strangulated three days the faradic current was applied, first to the hernia itself without any result; but afterwards, when one of the electrodes was placed in the rectum, and the other on the tumour, the latter began to yield, and in a very short time passed up into the abdomen.

HYDRARTHROSIS.—Effusions into the joints have been removed by different forms of electricity. In obstinate chronic cases electrolysis is indicated, in recent cases the external application of moderately powerful currents will suffice. Althaus recommends the constant current in such cases, and states that in the severe forms the magneto-faradic is preferable to the volta-faradic current. Van Holzbeck records two cases, in which the knee-joint was affected, cured by electro-puncture. Tripier treated one case of a similar character, in which there was considerable effusion, by the constant current externally; two applications of twenty minutes' duration each removed it entirely. I have in three instances been successful with the continuous current applied by moistened electrodes round the joint; the power used extended to fifty cells, and the time occupied was in each case about twenty minutes.

HYDATIDS.—Eight cases of hydatids of the liver have been successfully treated by Messrs. Durham and Cooper Foster by electrolysis. No cases are recorded of the destruction of hydatid tumours in other organs, but it is reasonable to suppose that electrolysis would be equally safe and effective wherever applied, as it is free from danger, and is not liable to set up suppuration in the cyst.

HYDROCELE.—Obstinate cases have been cured by galvano-puncture by Ruschenberger, Scoutetten, and Prof. Petrequin; farado-puncture has been successfully used by Lehmann and Tripier. Both these methods are very painful, and not more effective than the gentler means first suggested by Dr. Althaus, and employed successfully by Dr. Friedlaender, of Vienna, and myself—viz., to place the negative pole only in the fluid, and the positive externally. In this manner I have destroyed a number of hydroceles, varying in capacity from two to thirty ounces.*

HYPOCHONDRIASIS.—This disease is most materially benefited and often entirely removed by central galvanization (see page 53). The ascending current as a rule is to be preferred, although I have had very satisfactory results with the descending, and also with general faradization. My present experience would lead me to apply the continued and interrupted current on alternate days, if the disease did not yield readily to the central application of the continued alone.

HYSTERIA.—Benedikt and Beard and Rockwell advise general faradization as a means of allaying the highly excitable state of the peripheral nerves. I have found a direct appeal to the cerebro-spinal and sympathetic systems by the continuous current more permanently useful. The applications should be very mild, of uniform strength, and repeated daily, as nearly as possible at the same hour. Electro-therapeutists generally, place more reliance on this mode of treatment than on the interrupted current.

ICTERUS.—Jaundice from impaction in the ducts has been removed by the faradic current. One large electrode covered with moistened sponge is pressed rather forcibly against the portion of the back, corresponding to the position of the gall-bladder; the other electrode, also covered with moistened sponge, is placed over the anterior edge of the liver, and a rather powerful current applied. In a manner somewhat similar to this, Professor Gerhardt, of Würzburg, has cured several cases of *catarrhal* jaundice.* Beard and Rockwell cured rapidly and permanently a case of jaundice complicated with gastralgia of six months' standing by general and local faradization. Two cases of obstinate jaundice treated by me recovered slowly after a persistent course of local faradization. In one case of partial jaundice, complicated with vertigo, tinnitus, and tingling in the hands and feet, where the stools had been deficient in bile for nineteen months, in spite of all the usual hepatic remedies, general galvanization was employed in conjunction with local faradization. After three applications of the latter, the stools showed indications of increased biliary excretion, and at the end of twelve applications had returned to their natural state. The other symptoms yielded also.

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* For details of a case successfully treated by me, see Althaus, "Medical Electricity," 3rd edition, p. 672.

ILEUS.—In two most severe cases in which all the ordinary remedies had failed, and the patients were sinking rapidly, Dr. MacCormac, of Belfast, successfully applied galvanism. The negative pole was applied to the spine, and the positive was "promenaded here and there over the abdominal surface, but preferably in the lines of the great intestines." One application only was required in each case; the patients evacuated large quantities of fæces, followed by speedy relief and lasting recovery.[*] Dr. Clemens, of Frankfort, has successfully treated invagination by first administering one or two tablespoonfuls of metallic mercury, which settled down at the seat of the invagination; the negative electrode was applied over the supposed seat of the disease, and the positive placed in the rectum. Voltaic alternatives were used.[†] From its influence over the contractile fibre-cells of the intestines, the faradic current should have a powerful effect on such cases.

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* For details of his cases, see "Berliner Klinische Wochenschrift," 6th July, 1873.

IMPOTENCY.—Every form of electricity has been employed successfully in this disease. Westring, Schultz, and Roubaud used the constant current; Stacquez, the Leyden jar; Duchenne and Althaus, the faradic current. Where the disease is not dependent on local causes, but has a central origin, galvanization of the cord, especially that portion of it which contains the genito-spinal centres of Budge,[‡] holds out the best hopes of permanent recovery.

Beard and Rockwell report eight cases successfully treated, in which either current was used indifferently. I have had excellent results with central galvanization and local faradization on alternate days, and can recommend this method to the profession, as I have never found it fail in any case where, from the nature of the lesion, treatment was indicated.

INFRA-MAMMARY PAIN.—Usually felt beneath the left mamma. These cases are very common in delicate females, and if not connected with incipient lateral curvature, yield rapidly to the continuous current.

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[*] For details of these cases, see Althaus, *op. cit.*, p. 643.

[†] *Vide* ibid.

[‡] Virchow's "Archiv," 1859, p. 115.

Irritable Uterus.—See Uterus.

Lacteal Secretion, suppression of, from fright, fever, mammary inflammation, &c. Gentle faradization of the mammæ has in numerous instances restored the secretion. Aubert and Bequerel were the first to employ this means. Althaus has treated several cases with good results. Dr. Skinner, of Liverpool, has been successful also. Out of seven cases faradized by me, the treatment brought back the flow in five.

Lead Palsy.—See Paralysis.

Lupus, Spreading, of the face.—Mr. Bryant removed one of four years' standing by the galvanic cautery; the wound healed kindly, and five months afterwards it was difficult to discover where it had been, as the skin had returned to almost its natural state.

Locomotor Ataxy.—In the earlier stages of this disease, no remedy at all approaches galvanism in its power of arresting it. In the later stages, when wasting of the nervous matter of the cord has taken place, no treatment can avail, but many of the most distressing symptoms may be relieved by the constant current. The intense pains which usually accompany this disease, and which owe their existence most probably to irritation of the vaso-motor nerves, inducing tetanic spasm in the muscular coats of the arteries, may be relieved by galvanization of the sympathetic, as these nerves are only to be reached through it.

MALE—Diseases affecting the sexual apparatus in.—All errors of function in these organs, have been successfully treated by electricity. Westring, Stacquez, Schultz, Roubaud, Althaus, Duchenne, Beard and Rockwell,and the present author have recorded cases, where excellent results have been obtained in every form of functional defect, by the employment of all the varieties of electricity.

METEORISM.—Extreme distension of the intestines is best combated by faradism, as its action on the contractile fibre-cells is very powerful, but galvanism has also been employed with advantage. Althaus relates one case of immense distension of the stomach and bowels by gas (after ovariotomy) which was so great as to threaten life; he applied faradization four times with complete success. In another case of not so serious a character five applications of galvanism removed the ailment. In a number of cases of flatulent distension, of a troublesome but not dangerous nature, which have come before me from time to time, I have rarely failed to relieve by the faradic current alone, and the advantage gained has been in most instances permanent. One patient who suffered much from a generally lax state of the whole alimentary canal, coupled with most annoying flatulence and loss of tone in the sphincter, was completely cured by twenty applications of a constant current of fifteen cells. The positive pole was held in the mouth, the negative placed in the anus and lower portion of the rectum, and retained for five minutes at each sitting.

MIGRAINE.—See Neuralgia.

MIND, DISORDERS OF.—Where actual degeneration of brain tissue exists, no benefit can be expected from electricity in mental disorders; but where, as in the great majority of cases of mental alienation, there is great molecular perturbation in ultimate brain tissue without actual lesion, much may be done to relieve the patient. Dr. Arndt, who has devoted much time to the investigation of this subject, considers faradism a powerful stimulant of diseased nervous centres, and therefore an excellent remedy in cases of simple atony of the brain, depression, or paralysis of function; he has found it useless in melancholia, and mischievous where this is combined with distressing ideas of persecution, &c.; in apathetic idiots he has known it produce fainting fits. In recent cases of insanity, where there is a general disturbance of nutrition, he has seen much benefit accrue from the employment of the constant current. He reports five cases so treated, with very beneficial results. Dr. Williams, of Hayward's Heath, restored two cases of melancholia attonita by a few applications from a forty-cell Stöhrer's battery. Benedikt relates three cases in which the mental symptoms were much improved by galvanism.*

NÆVUS.—The galvanic cautery has been frequently employed for the destruction of nævi; out of 130 cases collected by Maas and operated on principally by Professor Middeldorpf, of Breslau, 112 were completely cured, and three died from the effects of the operation. Electrolysis is infinitely superior to the cautery in the removal of nævi; although its action is slower, no danger whatever attends its employment, and the changes which take place in the nutrition of the parts induces complete and permanent obliteration of the tumour. Althaus was the first to employ this method; since then it has been successfully used by various surgeons and electro-therapeutists, including Bryant, Beard and Rockwell, Lincoln, Grote, and myself; in two out of seventeen cases electrolyzed by me the tumour returned after a short time, but a second application, in which both poles were introduced into its substance, was completely successful in each case.

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* For an excellent abstract of our present knowledge on this subject, see Althaus, *op. cit.*, p. 483.

Nervousness.—Nervous exhaustion. Galvanism has a most marked effect upon this condition. Where the exhaustion is cerebral only, and characterized by irritability of temper, impaired mental grasp, hesitation of speech, flushings, muscular exhaustion, drowsiness during the day, &c. &c., catelectrotonus refreshes and restores the suffering nervous centres; where restlessness and sleeplessness at night are prominent symptoms, anelectrotonus is to be preferred. Where the spinal cord is most at fault, as in nervousness associated with imperfect digestion, oxaluria, excess of urea, urates or phosphates in the urine, &c. &c., galvanization of the cord alone will frequently cure; but as a general rule central galvanization, from its extensive range of action, yields the best and most certain results.*

NEURALGIA.—We have the high authority of Anstie for saying that for this disease "the constant current is a remedy unapproached in power by any other, save only blistering and hypodermic morphia, and even the latter is often surpassed by it in permanence of effect, while it is also applicable in not a few cases where blistering would be useless or worse."† The current should be weak, and not applied longer than from five to ten, or at most fifteen minutes at a sitting; these should be daily, and always as nearly as possible at the same hour. The main object should be to direct the influence of the current upon the posterior nerve root. Benedikt recommends the current to be directed towards the seat of mischief, and says that the proportion of cases in which this method succeeds is very large. Althaus and Eulenburg consider that the positive pole should be placed on the part to be affected, and the negative on an indifferent spot; Russell Reynolds, Buzzard, and Anstie, who have all had much experience in this disease, while they admit these two observers to be theoretically right, conclude that it is immaterial in what direction the current flows provided the seat of the disease is within the circuit. In migraine, Eulenburg and Anstie speak highly of galvanization of the brain in the transverse direction, but warn the operator to apply a very gentle current for not longer than half a minute at a sitting.

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* *Vide* "Nervous Exhaustion and the Diseases induced by it." 9th edition. By H. Campbell, M.D. Longman and Co.

† *Vide* "Neuralgia." By F. A. Anstie, M.D. Macmillan and Co. 1871. p. 200.

In neuralgias of the face a mild current only should be applied. For the limbs a more powerful one may be used. In neuralgic affections of the larynx and pharynx, one pole placed at the nape of the neck and the other on the pomum Adami will almost invariably cure, after a few applications. Eulenburg reports favourable results in three cases of angina from a current of thirty cells. The negative pole was placed on the lower cervical vertebræ, the positive on the sternum. Neuralgia of the neck of the bladder has been materially relieved by Anstie, by a current of twenty cells passed from pubis to perineum. Neuralgias of the urethra, testicles, uterus, rectum, &c. &c., have been entirely removed by the local application of the constant current.

In an infinite variety of neuralgias which I have treated by the constant current, I have been almost invariably successful in recent cases, moderately so in those of somewhat lengthened duration, and rarely so in those of very long standing in aged persons, where no doubt structural changes had taken place of too grave a character to yield.

ŒDEMA.—Temporary benefit has been frequently produced by the application of either current, in cases depending on disease in the liver or kidney. When it arises from accidental causes, absorption is rapid and the relief permanent.

PARALYSIS.—*Cerebral hemiplegia*, the result of cerebral hæmorrhage, may be materially improved, and even removed by galvanism, provided it be employed at the proper stage of the disease—*i.e.*, when all acute symptoms have subsided, and the paralysis is kept up by pressure of a clot on the cerebral substance. Benedikt relates a case in which his patient, aged sixty-nine, had an attack of hemiplegia on the right side, with loss of consciousness and speech. Ten months afterwards he had recovered the use of the lower limb, but the muscles of the fore-arm and hand, except those in the ball of the thumb, remained helpless, the flexors and pronators were contracted, and electro-muscular contractility was still much impaired. Galvanization of the left cerebral hemisphere in six applications enabled him to flex the wrist and phalanges, and to extend the metacarpo-phalangeal joints fairly well, and the phalangeal joints pretty well. Althaus combines peripheral with cerebral galvanization in cases of hemiplegia, with very satisfactory results, and I can from my own experience fully bear him out in his statement, that patients of this kind progress more rapidly to recovery from the combined treatment.

It is important to fix the earliest period after the attack when electric treatment may be resorted to. Remak advises an early galvanization of the sympathetic and cerebrum to promote absorption of the clot. Legros and Onimus advise this procedure as early as the eighth day; the current very feeble and gradually increased to a point still very mild, and all shocks to be avoided. Althaus, on true pathological principles, lays down the rule that galvanic treatment should be postponed until all danger of cerebral fever has passed off, and advises the applications not to be resorted to earlier than from fourteen to eighteen days after the seizure, but warns us to wait no longer. The prospects of recovery are much diminished by delay. I entirely agree with him in this advice, for pathology shows that atrophy of the nervous fibres, of the antero-lateral columns, of the opposite side of the cord, almost always ensue, in cases of paralysis which have remained unrelieved for six months and upwards. Where the paralysis has existed for some months without electric treatment, faradism should be resorted to for the limbs, while the galvanic current is employed, as in the more recent cases, to the brain and sympathetic.

Syphilitic hemiplegia, which resists the action of iodide of potassium, is generally relieved in a very marked degree by the constant current. Many cases might be cited in confirmation of this statement.

Cerebral exhaustion will frequently produce partial hemiplegia, which is usually limited to the arm and hand. Galvanization of the opposite cerebral hemisphere almost immediately removes it.

Paralysis, Spinal (paraplegia), from hyperæmia or anæmia of the cord, the consequence of cold, over-exertion, post-partum hæmorrhage, a fall on the back, typhoid or other zymotic fever, yields readily to the constant current, especially when applied early in the disease, and combined with general faradization. Where the paralysis depends on actual lesion of some portion of the cord, on caries of the vertebræ, or on the pressure of tumours, electricity may relieve some of the more pressing symptoms, but cannot restore. Cases depending on myelitis, meningitis, congestion, and non-inflammatory softening, often improve rapidly up to a certain point under electrical treatment, and then stop short, no further improvement manifesting itself, no matter how long the treatment may be continued.

Paraplegia of a syphilitic origin usually yields to large doses of iodide of potass, but where it is of long standing and intractable, the constant current may be employed with every hope of success. Cases are on record in evidence of this. In one of nineteen years' duration, where the walking powers were almost gone, the patient was able to walk fairly after twenty applications to the spine and nerves of the limbs.

Paralysis of the sympathetic is a term applied to a peculiar form of paralysis, described by Meyer and Driessen, which attacks both upper and lower limbs, and is sometimes associated with general nervous symptoms, and considerable disturbance in nutrition and sensibility. Cases of this description are recorded by both these physicians, in which the proceeding known as galvanization of the cervical sympathetic removed the disease entirely.

Hysterical paralysis usually takes on the paraplegic form, although sometimes it attacks only one set of muscles. When there is a high degree of excitability present, the descending current applied to the spine is the best treatment; where much depression, the ascending answers best. Applications of the form indicated, combined with faradization of the affected limbs or muscles, usually completes the cure in a short time.

Rheumatic paralysis.—Certain sets of muscles, and sometimes individual ones, become paralysed from the effects of rheumatism; where this is clearly the cause, faradization may be resorted to with certainty of success. My own experience, as well as that of electro-therapeutists generally, leads me to speak very positively under this head.

Paralysis from lead-poisoning. — The muscles usually affected are the extensors of the hands and fingers. Their electro-muscular contractility is always diminished, and sometimes entirely lost; electro-muscular sensibility is also impaired. When electro-muscular contractility is quite gone, the galvanic current should be applied to the muscles for a few minutes, and then changed for the faradic, which should be continued for fifteen minutes. As soon as the muscles begin to contract under the faradic current, the galvanic may be suspended. Eulenburg has been successful in several cases treated in this manner. Dr. W. G. Smith, of Dublin, cured a case by faradization. Dr. Anstie was equally successful, but employed the constant current for eight weeks, when faradic excitability having returned, the interrupted current was applied to the muscles for a month, when both their bulk and power were almost completely restored.*

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* "Trans. Clin. Soc. Lond." vol. iii. 1870.

Traumatic paralysis.—Loss of motor power in a muscle, or set of muscles, from injury to the nerve supplying it, is curable in direct proportion to the amount of mischief done to the nervous tissue. This peripheral form of paralysis may exist from the pressure of effusions or tumours, as well as from contusions or wounds from steel or gunpowder. In electric treatment, some doubt exists whether the absorption which takes place in these cases, of the effused blood and serum at the seat of the injury, is from natural causes or from treatment. Erb Cheron and Mitchell consider it best in all cases to apply the constant current, as soon as the condition of the wound will allow. The last-mentioned physician, whose experience in these cases has been most extensive, believes that electricity sustains the nutrition of the parts, and keeps the muscles in good condition to respond to the nervous influence when it is restored.

Diphtheric paralysis.—Usually appearing the second or third week after the diphtheric exudation, affects the motor tracts in much the following progression:—Soft palate, muscles of the eyes, lower extremities, upper extremities, muscles of the trunk, including the muscles of respiration. Galvanism and faradism combined offer the best chances of recovery. Dr. Greenhow* treated one case successfully by faradism alone. Dr. Krafft-Ebing† treated a case seventeen months after the primary disease, in which there was a high degree of wasting in the muscles supplied by the crural, obturatorius, and glutæi nerves. The cord nerve and plexus nerve currents were used, together with faradization of the wasted muscles, for a month. Muscular nutrition and motor power gradually returned, and eventually the patient became quite well. Two cases of diphtheric paralysis treated by me in the early period of the attack yielded rapidly to galvanism and faradism on alternate days.

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* "Trans. Clinical Society," 1871.

† "Deutch. Archiv," vol. ix. p. 123.

Paralysis of the nerves and muscles of the eye.—Benedikt strongly recommends galvanism in these affections; Meyer and Wells, faradism; Althaus, faradism and galvanism. The last-mentioned physician records some cases in which complete success followed both methods. I have no doubt that where the muscles are much wasted the interrupted current should be used after the continuous has made some impression on the nerves.

Paralysis of the face, from rheumatic inflammation of the portiò dura. In recent cases electricity rapidly cures, as I have more than once had an opportunity of observing. Cases of long standing are often much relieved. Reynolds materially improved one which had existed fourteen years: the current employed was the faradic. Beard and Rockwell completely cured by galvanism and faradism five out of eight cases; of the remaining three one was decidedly benefited and two not benefited.

Paralysis of the vocal cords has been successfully treated by galvanism by Grapengiesser, of Berlin, and by Mackenzie, Althaus, J. Tanner, and myself by faradism. In one of my cases the patient, a tall, leuco-phlegmatic girl, aged seventeen years, who had been voiceless for two months, recovered her voice a few hours after the first application. Beard and Rockwell report the case of a young lady, in whom the aphonia had existed four months, cured by three faradic applications.

Paralysis of the sphincter ani, depending on local disease, is curable by faradism. I have succeeded in one case.

Paralysis agitans.— Central galvanization and local faradization may be employed in these cases. Reynolds cured one case by galvanism. Jules Chérin, of Paris, employed galvanism in seven cases; two were cured, two much improved, and the remaining three, although much improved in their general condition, had no improvement in the tremor.

Infantile paralysis, characterized by wasting of bone and muscle, reduced temperature, diminished electro-muscular contractility, and some anæsthesia in the paralysed limb, which is also much shorter than the healthy one. Beard and Rockwell report nine cases treated by galvanism; of these four recovered, one nearly recovered, two were decidedly benefited, and two were not benefited. Drs. Reynolds and Althaus recommend the alternate use of faradism and galvanism. I can speak highly of this method, as I have found much better results from it than from either current alone.

PHOTOPHOBIA.—Mr. Hewson reports thirty-two cases of this disease, due to strumous inflammation of the cornea in children, cured by the application of the constant current; the negative pole was placed on the supra-orbital foramen, the positive on some part of the face. From one to three applications were sufficient.

RESPIRATION, INDUCTION OF ARTIFICIAL, BY ELECTRIZATION.—*In cases of apparent death from drowning, or suffocation from inhalation of poisonous gases, or in the asphyxia of new-born children.*—The faradic current is superior to the galvanic in its effects, but where this cannot be obtained at the required moment and the other is at hand, the latter may be employed if the circuit is frequently broken. Where faradic irritability is lost, the galvanic current should always be used.

Two assistants are required—one to place and retain in a fixed position the head, shoulders, and arms of the patient; the other to be ready to assist the respiratory movements by pressure.

Graduate the current to a strength sufficient to produce vigorous contractions of the muscles of the ball of the thumb, then press (one on each side) the sponge electrodes, which should be of large size and well moistened, firmly over the phrenic nerves at the outer borders of the sterno-cleido-mastoid muscles, and at the lower end of the scaleni muscles, or one electrode may be placed over the phrenic nerve of one side and the other in the seventh intercostal space of the same side.

The current should be withdrawn and renewed three times in a minute, while the assistant presses firmly on the abdomen, and occasionally pauses to note the effect.

If, after a short time, no inspiratory movements appear, increase the strength of the current.

Care must be taken not to apply the pole in the neck indiscriminately, especially if the galvanic current be used; the operator should be certain of the motor point of the phrenic nerve (see page 57); a reckless application in the neck has produced instantaneous death in a person slowly recovering from opium poisoning.* On the other hand, frequent failures occur in attempts to restore suspended animation by electricity, where we may reasonably believe the operator would have been successful if he had been master of his instrument and of the anatomy of the parts to be affected.

In stillborn children, the warm bath may be alternated with electrization of the phrenic. In one case, reported by Pernice, the child was born to all appearance dead, but respiration was established in about forty minutes by this method.

RHEUMATISM and RHEUMATIC GOUT, when subacute or chronic, frequently yield to general faradization, coupled with galvanization of the affected joints or muscles. The effect of the continuous current on the inflamed joint is to relieve the pain, reduce the inflammation, and if effusion is present, cause its absorption. The positive pole should be placed on the seat of pain, the negative on an indifferent spot; the applications should be mild. Where callosities or anchyloses exist, the prognosis is not so favourable, but prolonged application of the continuous current hold out reasonable hopes of amendment; in one case, where the enlargement of the knuckles on both hands amounted to extreme deformity, I was very successful in reducing their size, and restoring a fair amount of mobility in the joints, by steady perseverance with mild continuous currents for three months. Muscular contractions after rheumatism, which resist routine treatment, are almost always removed in the same manner. Where loss of power and wasting in the muscles follow a very severe attack, faradization of the wasted limb rarely fails to restore it. Rheumatism of the shoulder of many years' duration has been cured by a few applications of faradism. Lumbago, which is a rheumatic affection of the muscular tissue around the loins, yields to either current.

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* See Beard and Rockwell, p. 592.

SCIATICA.—The continuous current is very successful in removing this painful and troublesome ailment. It has also been cured, but not so rapidly, by faradism. In very obstinate cases, especially of many years' standing, where external applications have failed, Benedikt recommends placing one electrode on the rectum, and the other on the sacrolumbar region, so that the current may flow more directly through the nerve. Where sharp lancinating pains are a feature of the attack, a current should be sent through the lumbar portion of the spinal cord, in addition to the other application.

Scirrhus.—See Cancer.

Scrivener's Palsy.—This disease is most probably due to deficient nutrition in the central ganglia, from which arise the nervous influences which preside over certain special movements of certain muscles, as it does not extend to other movements of the affected part. If this view be correct, the seat of the disease must lie in the upper portion of the cord, and to this treatment must be directed. The positive pole should be placed on the upper vertebræ, the negative in the stylo-mastoid fossa; a current of fifteen to twenty cells may be used, and the length of the applications should not exceed ten minutes at a sitting. The results of this treatment, if continued long enough, are most satisfactory. Dr. Althaus speaks in the strongest terms of its good effects, and I can do so also. Dr. Poore, in very obstinate cases, combines rhythmical exercises of the hand with the galvanic treatment, but I have never seen a case in which it was necessary.

Sexual Hypochondriasis.—This ailment is not uncommon amongst persons who have abused their sexual organs. Excess produces exhaustion and nervousness. They then become gloomy and despondent, and are haunted by a constant dread of loss of virile power. Faradization of the ischio-cavernosus and bulbo-cavernosus muscles, and occasional galvanization of the cerebro-spinal axis, added to continent habits, soon restore them.

Skin Diseases.—Drs. Beard and Rockwell have recently treated a number of cases of acne, prurigo, and eczema by central galvanization alone, without any application to the diseased surface, and the results have in some instances been more satisfactory than any other method of applying electricity in these diseases. Not only after medical treatment has failed, but after ordinary localized electrization has accomplished but little, central galvanization was often rapidly and permanently efficacious. The doctrine of the dependence of certain diseases of the skin on the nervous system, which has of late years been gaining ground, is demonstrated by these results in a remarkable manner.

Eczema.—Localized galvanization greatly relieves the itching and sometimes cures; but central galvanization, acting on the central nervous system, improves the peripheral nutrition in so remarkable a manner, as to frequently cure the disease in a very short time. Drs. Beard and Rockwell permanently cured a severe and obstinate eczema of the leg, with intolerable itching, which had resisted all treatment during a period of eight years, by central galvanization. Also one of twenty years' standing, which attacked by turns, various parts of the body. In a number of cases where thorough cure was not effected, there was relief of the intolerable itching and distressing pain.

Acne indurata.—A case of hereditary acne indurata of the face and back was treated by Dr. J. H. Sterling, by eighteen applications of central galvanization alone, and the disease disappeared.

Acne rosacea.—Drs. Beard and Rockwell have treated these successfully by both local and general galvanization.

General prurigo.—A case of six years' standing, in which the itching was intense, was almost entirely cured by fifteen séances of central galvanization, by Drs. Beard and Rockwell.

Lichen ægrius, General pityriasis, Pityriasis capitis, Psoriasis of the arms and legs of thirty years' standing, Herpes circinatus, Herpes zoster associated with neuralgia, Elephantiasis of the legs.—All these diseases have been treated electrically by Drs. Beard and Rockwell. In some the improvement was decided and permanent, in others relapses occurred; but in all relief was given to the painful and disagreeable symptoms.

Drs. Beard and Rockwell note the following, in reference to the employment of electricity in skin diseases:—

1. The rapid relief of the itching and pain of eczema, prurigo, and herpes, by local applications.
2. The relieving and curative effects of central galvanization in prurigo and eczema.
3. The fact that herpes, prurigo, and eczema yield in some instances very rapidly, while psoriasis and pityriasis are slow and obstinate.
4. The tendency in some cases to relapse, while in others the relief is more permanent.*

SPINAL IRRITATION.—True hysterical hyperæsthesia of the spine, has for its leading features spinal tenderness, sensations of heat and burning, fugitive pains, chills, formication, yawning, nervous cough, nausea, palpitation, irritable bladder, constipation, insomnia, muscular contractions, &c. The general tenderness of the spine is usually superficial, but there are always points of tenderness where pressure induces considerable pain, and secondary objective symptoms, in organs receiving part of their nervous supply, from centres seated in that portion of the cord. When the tender spot is in the cervical vertebræ, pressure induces nausea and vomiting; when in the dorsal, severe gastric disturbances; when in the lumbar, derangements of the bowels and pains in the lower limbs. The trépied hystérique of Briquet consists of pain at some point in the dorsal vertebræ, in the epigastrium and the left hypochondrium.

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* See "Clinical Researches in Electro-Surgery," by Drs. Beard and Rockwell." New York. 1873.

Dr. Anstie speaks in very high terms of the efficacy of faradization in this disease, when there is much cutaneous and mucous tenderness.* Beard and Rockwell advise galvanization of the cord and sympathetic, and cite cases. I have found galvanization of the cord, with special reference to the tender spots, quickly remove the most pressing symptoms; the positive electrode over the seat of tenderness, and the negative as far below it on the spine as the position will admit, with a mild current of short duration, rarely fails to subdue the hyperæsthesia. As the irritation is most likely associated with capillary contraction and bloodlessness, instead of capillary paralysis and congestion, the local application of the electrode to the tender spot seems to me to be the treatment most likely to produce a permanently beneficial effect.*

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* See "Neuralgia." By F. E. Anstie, M.D. P. 239.

SPERMATORRHŒA.—No treatment, internal or otherwise, is equal to galvanization of the spine in this disease. I can urge this method upon the profession from large experience of its action. Local electrization is mischievous, not only by the undue excitement it produces, but by keeping the patient's attention constantly fixed on the seat of his malady.

STRICTURE, LACHRYMAL.—Stricture of the lachrymal duct is easily curable by electrolysis. The ordinary metal stylet employed in this affection may be used as a negative electrode, the positive may be applied to any part adjacent. The current should be exceedingly mild and not applied for longer than five minutes at a time; five applications are usually enough. Absorption of the submucous areolar tissue is effected in this manner, and the thickening on which the stricture depended is removed.

STRICTURE, URETHRAL.—The electrolytic action is the same here as in the foregoing. The negative electrode insulated within an eighth of an inch of the point is passed down to the seat of the stricture, and the circuit closed by placing the positive electrode on the inner surface of the thigh; the metallic point of the negative electrode is then pushed forward through the whole course of the stricture and slightly beyond it. There is scarcely any pain in the operation, and one application is usually sufficient, although in some cases I have had to repeat it more than once. The calibre of the urethra increases for a short time after the operation, owing to progressive absorption of the peri urethral effusions which were the original cause of the stricture. Messrs. Mallez and Tripier, of Paris, treated thirty-one cases. In thirty cases the result was satisfactory and permanent; in the one left, death ensued in a week after the operation, owing to disease of the kidneys. This last should not have been operated on in consequence of the fatal disease from which he suffered.*

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* See Russell's "System of Medicine," vol. ii. p. 697.

Brenner, of St. Petersburg, records thirteen cases successfully treated by him; in all the pain was slight. I have frequently removed urethral stricture in this manner, and always without unpleasant consequences afterwards. In one of my cases considerable hæmorrhage followed the withdrawal of the electrode, but on examination it was found that in the battery (a portable one) which I was using, the maker had, without informing me of it, reversed the poles. I had therefore been applying the positive electrode within the urethra, a proceeding always to be avoided.

TINNITUS AURIUM.—Pathologists differ so much as to the cause of this malady, that we may reasonably suppose various morbid processes in the ear produce it. Hence the capriciousness of electric as well as other treatment: in some instances the tinnitus yields to simple inflation of the middle ear, as I have more than once had reason to note; in others nothing seems to remove or even relieve it. In one case of noises in the head and ears existing for ten years, Brenner employed galvanism with considerable but not complete removal of the symptoms. Beard and Rockwell consider that "no cases of tinnitus, whatever the supposed pathology may be, should be considered hopeless until after the failure of persevering and varied electrization." I have used both the faradic and galvanic currents frequently in tinnitus, and with very varying results. On the whole, my experience would lead me to follow Benedikt's advice, and trust mainly to galvanization of the cervical sympathetic, for which he claims good results. As the disease must often depend on impaired nutrition of the hearing apparatus generally, or of the auditory nerve, or the chorda tympani, it appears to me his treatment is the most likely to do good.*

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* See "De la guérison durable des rétrécissements de l'urèthre, etc." Paris. 1870.

TUMOURS.—Where electrolysis has been employed with skill, it has been invariably successful in the removal of all tumours, except malignant and fibroid recurrent ones; the former of these have, when operated upon early, in Dr. Neftel's manner, been destroyed; the latter have not as yet been treated electrolytically, by any one who was master of the subject, as the failure in the only two cases recorded depend, in one case on the introduction of the wrong electrode into the body of the tumour, and in both on a too weak application of the current.

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* See the author's work on "Deafness treated by Electrolysis, &c.," already referred to.

Ovarian cysts.—Dr. Fieber, of Vienna, successfully electrolyzed one occurring in a woman aged thirty-two years.

Cystic tumours.—I have removed these from various parts of the body by electrolysis. Beard and Rockwell removed one which had existed on the forehead of a lady for forty years—a large one in the right axilla—and another in the submaxillary region.

Sebaceous tumours.—Dr. Althaus has removed a sebaceous tumour of the nose by electrolysis. I recently removed one at the back of the neck; the base was nine inches in diameter, and completely covered the cervical vertebræ. At first, owing to the timidity of the patient—a lady—one needle only was applied twice a week and the tumour notably decreased, but slowly; after ten applications, five needles were introduced three times a week, when the tumour began to be rapidly absorbed, and in a short time entirely disappeared. In another tumour of the same kind, situated on the scalp, ten applications of three needles, entirely removed it; this tumour had been removed some years previously by an eminent operative surgeon, but soon returned. Three years have now elapsed since its removal by electrolysis, and there is no symptom of its return.*

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* See further on this subject the author's paper on "Electro-Surgery." Alexander. London. 1872.

Ulcers.—Troublesome and sluggish ulcers and bed-sores are rapidly cured by faradization or galvanization. Mitchell, Henry, Rushenberger, and Nunn have employed with complete success the interrupted current in ulcers, bed-sores, and sinuses in the breast after mammary abscess. Reparation is induced by stimulation of the vaso-motor nerves, and consequent increase of blood and nutrition in the unhealthy tissues.

Mr. Spencer Wells has employed the constant current in similar cases with the best results; he concludes from his experience that no other means is so capable of producing a rapid growth of healthy granulations. Beard and Rockwell have cured syphilitic ulcers and tubercles, which resisted other treatment, by the same current. In a case of sloughing ulcer of the calf, which threatened to extend to all the adjacent soft parts, and which rapidly increased in spite of all treatment, I arrested the mischief, and produced a marked improvement in its condition in a very short time by the constant current, which eventually healed it.

Uterus.—In chronic metritis, and enlargements of the organ from defective involution after childbirth, as well as other uterine diseases, faradism has been largely employed by French surgeons, especially Beau, Tripier, and Fano. The minute structure of the organ, composed as it is of organic muscular fibre disposed in three layers, connected and interlaced with nucleated areolar tissue, is powerfully affected by the intermittent current, and as the diseases to which it is subject are for the most part atrophy of the muscular fibres, effusions into the connective tissue, with actual increase of the latter, it can be easily understood how the muscular contractions induced, promote absorption and check overgrowth in the connective tissue.

In irritable or neuralgic uterus I have employed galvanism with good results; displacements of the organ have been treated electrically, but not with results so satisfactory as to warrant a belief that it will supersede mechanical appliances; hæmorrhage from the uterus is more easily and certainly controlled by faradism, than by any other remedy. (See Hæmorrhage.)

VOMITING, OBSTINATE, if not from malignant disease, usually subsides rapidly under faradization. M. Popper, Beard and Rockwell, and Le Coniat have been very successful by this means. The last claims to be able to cure at least 90 per cent. of the persons who suffer from sea-sickness, and also to control the nausea and vomiting of pregnancy; he applies a solution of sulphate of atropine (one grain in the ounce) over the stomach in addition to the faradic current; this may detract somewhat from the credit of the latter, although not much, as the solution is laid on the unbroken skin and can scarcely be said to get into the system.*

WRY-NECK (Torticollis).—In the early stages this may be relieved or cured by electrical treatment, but when it has existed even for a few months only it is very intractable. Even when relieved at this stage it is very liable to return. Galvanism holds out a better chance of success than faradism, and the benefit derived from it often goes on slowly increasing for some time after the treatment has ceased.

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* See Dwinelle's account of Le Coniat's method in *New York Medical Journal*, 1869.

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